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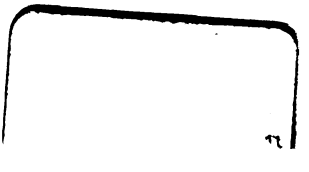
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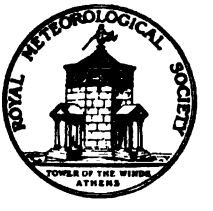
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THE INTERNATIONAL BALLOON ASCENTS, JULY 22–27, 1907.

Reports by W. H. DINES, F.R.S., J. E. PETAVEL, F.R.S., W. A. HARWOOD, and Prof. W. E. THRIFT, M.A.

[Read November 20, 1907.]

I.—THE REGISTERING BALLOON ASCENTS IN ENGLAND OF JULY 22-27, 1907, PRELIMINARY ACCOUNT.

BY W. H. DINES, F.R.S.

THE International Aeronautical Commission has for many years past set apart the first Thursday in each month for the ascent of kites and balloons; but at the Conference held at Milan last year, it was decided to make a special effort to obtain information on a series of consecutive days, and the last week in July was finally decided upon for the purpose.

It is not worth while to attempt a full discussion of the results before the Continental figures are published, but since twenty-five balloons were sent up in England and Scotland during the week, and fourteen of these have been found, it may be of interest to give a brief statement about the method adopted and the results obtained.

The Meteorological Office, the Joint Kite Committee, the Manchester University, and Mr. Cave participated in the work. The Meteorological Office were responsible for nine balloons, namely five from Crinan on the west coast of Scotland, and four from their station at Pyrton Hill, Oxon. Mr. Petavel, aided by a grant from the Kite Committee, dispatched six balloons from Manchester; Capt. Ley, acting for the Committee, three from Sellack, near Ross, Herefordshire; and Mr. Cave six from Ditcham Park, Petersfield. Up to the present time, of these, three from Crinan, four from Manchester, one from Ross, two from Pyrton Hill, and four from Ditcham Park, have been found.

With one exception the instruments used were all made at Pyrton Hill, but since there was very little previous experience of this sort of work in England it was left to each observer to choose his own kind and size of balloon; and very largely to dispatch it at the time and in the manner that he deemed best.

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The instruments that were used are described in *Symons's Meteorological Magazine* for July 1906. Briefly it may be said that they leave a record scratched by two hard steel points on a small piece of sheet metal electro-plated with copper. The scale is very small, but the traces are read under a low power microscope. The marks consist of two lines roughly parallel; at least they would be parallel were there no change of temperature. In the usual form of trace these lines are about $\frac{1}{2}$ in. (12 mm.) long, and start about $\frac{1}{30}$ in. apart, diverging to perhaps $\frac{1}{10}$ in. at the top. The distance between the lines gives the temperature. Under a microscope it is easy to read this distance to about ·001 in., or ·025 mm., and this distance corresponds to about 1° C. Two independent observers taking the same trace and calibrating the instrument independently are not likely to differ in their readings by more than one or two degrees of temperature. The record of height is more uncertain. The atmospheric pressure recorded can be obtained with fair accuracy, but heights where the pressure amounts to only a few inches of mercury (under 150 mm.) are frequently reached, and at such heights a small error in the pressure means a large error in the height.

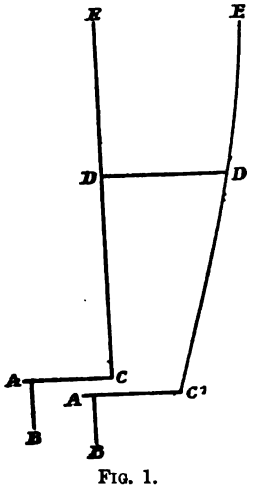


FIG. 1.

Fig. 1 shows the form of a good trace magnified four times. The instruments are roughly calibrated a few days before they are sent up. In general a spring holds the points off the copper, but an hour or so before starting, a wedge is inserted which presses down the spring and brings the steel points on the copper at the points A, A. The instrument is then lowered gently into water to a definite depth, and the increased pressure due to the water makes the two marks AB, AB. I am indebted to Mr. W. A. Harwood for his useful suggestion. The temperature of the water is recorded, and this temperature compared with the distance between the lines AB, AB gives the zero line of the temperature scale. The instrument is allowed to dry and then the copper is drawn along a short distance by hand, making the marks AC, AC′. These lines form the base lines of the pressure scale. The instrument is then sent up, and as the temperature falls the points separate and produce the trace as shown. The temperature is given by the length DD and the height by the distance from C′ to DD.

The figure shows an ideal trace, but however careful the observer may be after he has inserted the wedge he is certain to get a few scratches about the points C, C′. These do not matter. The wedge has a piece of red string tied to it, and on the label offering the reward, the finder is requested to pull out the wedge. He generally does so, but, if not, the shaking of the journey back produces two blurrs at C and C′. Still if the marks AB, AB are distinct the only result is that the trace is lost for about the first 1000 feet. If the marks AB, AB, cannot be found, one has to make the best guess one can at the centre of the blurrs, and use them as the starting-points.

In general the lines EC and EC′ are sharp and distinct, and if the

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balloon is sent up after or near sunset the up and down traces are generally almost identical, but the up trace is mostly distinguishable from the down. Occasionally thick blurred lines occur, notably so when two balloons arranged tandem are employed, but there is no difficulty about reading even in this case. The chief use of the lines AB, AB, the "water marks" as we call them, is to make sure that the standard temperature line has not been altered by the shaking of the instrument in transit to the place of ascent.

All the traces so far recovered have been readable, excepting part of one of Mr. Cave's, which was picked up in the Channel, off Bognor. One of the balloons from Crinan also fell into the sea, but the trace was quite legible. It might perhaps be worth while to electroplate with gold instead of copper. Probably owing to their lightness the meteorographs never seem to be injured by their fall. Each one, as soon as it is returned to Manchester or Pyrton Hill, is carefully calibrated, and I take this opportunity of expressing my indebtedness to Mr. W. A. Harwood, who, before the necessary apparatus was obtained at Pyrton Hill, calibrated many instruments for me at the physical laboratory at Manchester University.

Perhaps the most important matter about all balloon ascents is the question of solar radiation. The thermograph of these particular instruments depends on the contraction of a strip of very thin polished metal. It is therefore sensitive and not susceptible to radiation. It is further protected by a cylindrical case polished inside and out. At the earth's surface it is easy to see that it is but little influenced by solar radiation. On the other hand it is certain that when the balloon has been sent up in the middle of the day in the summer, and has not burst, the temperature near the top is influenced by the sun. Thus 32° F. has been recorded when – 40° F. might be expected, both on the Continent and in England. Quite apart from direct radiation on the meteorograph, it is easy to see that its ascent may be made in a column of air that has been warmed by contact with the balloon. There is a complete relative calm and most intense solar insolation, and a slowly ascending balloon may well be surrounded by a mass of air warmed by contact with the balloon. It is usual on the Continent to avoid the difficulty by rejecting all observations when the ventilation is insufficient, that, is to say, when the product, density of air, and vertical velocity fall below a certain standard. As our instruments carry no clock, we do not know the vertical velocity and cannot adopt this plan.

I prefer to send up the balloons a little before sunset, so that by the time they reach their highest point the sun may be near or below their horizon. By this means all doubt concerning the temperature is avoided. The vertical velocity of the balloon is immaterial or nearly so. If the balloons float at the same height there is ample time for the metal strip to take the temperature of its surroundings; if the motion is rapid there is a stream of air passing over it to render it sensitive. Since the change of temperature of the strip depends on the mass of air which has been in contact with it, and this mass varies as the velocity multiplied by the time, remembering that velocity is space divided by time, we see that the velocity cancels out. The objection to this plan is that the balloon is not seen to fall and hence there is less chance of finding it, and the time

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of flight is also unknown. It is, however, an exception for anyone to see the balloon fall, even when it falls during the daylight.

The results obtained are summarised in Table I. They will subsequently be published in detail by the International Aeronautical Commission, and until then it is hardly worth while to do more than give a rough statement of the results.

TABLE I.—Temperatures at Various Heights.

	July 23.	July 24.	July 25.	July 26.	July 27.	Mean.
Ground Level.						
Crinan	...	57	60	59	...	59
Manchester	59	57	57	59	...	58
Sellack	65	...	...	...	...	65
Pyrton Hill	...	60	59	...	...	59
Ditcham Park	...	64	63	...	59	62
10,000 Feet.						
Crinan	...	32	27	34	...	31
Manchester	35	30	41	37	...	36
Sellack	29	...	...	...	...	29
Pyrton Hill	...	19	33	...	...	26
Ditcham Park	...	30	39	...	27	32
20,000 Feet.						
Crinan	...	3	8	1	...	4
Manchester	1	−7	6	10	...	2
Sellack	−5	...	...	...	...	−5
Pyrton Hill	...	−3	2	...	...	0
Ditcham Park	...	5	12	...	−4	4
30,000 Feet.						
Crinan	...	−27	...	−24	...	−25
Manchester	−33	−47	−30	−20	...	−33
Sellack	−35	...	...	...	...	−35
Pyrton Hill	...	...	−30	...	...	−30
Ditcham Park	...	−18	...	...	−31	−24
40,000 Feet.						
Crinan	...	−40	...	−24	...	−32
Manchester	−52	−52	−38	...	...	−47
Sellack	−54	...	...	...	...	−54
Pyrton Hill	...	...	−51	...	...	−51
Ditcham Park	...	−24	...	...	...	−24
50,000 Feet.						
Crinan	...	−39				
Manchester	−50	−50	−37			
Sellack	−46					
Pyrton Hill						
Ditcham Park	...	−20				

Crinan	Lat. 56°6′ N.	Long. 5°33′ W.
Manchester	,, 53·29 N.	,, 2·14 W.
Sellack	,, 51·58 N.	,, 2·35 W.
Pyrton Hill	,, 51·38 N.	,, 1·0 W.
Ditcham Park	,, 50·57 N.	,, 0·47 W.

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As I have previously stated, I do not think too much importance must be attached to the precise height to which a given temperature is assigned in each ascent. The instruments are troublesome and difficult to calibrate without specially designed apparatus, and this apparatus is not yet completed. The sequence of temperature is certainly correct, and I have no doubt about the substantial accuracy of the values. Cases in which there is reason to assume the influence of solar radiation are omitted.

It has been known for some time that after a certain height is reached, the air temperature ceases to fall. This layer is of variable height, and is known as the region of the "great inversion." Some competent meteorologists have expressed doubt about this inversion, being inclined to ascribe it to instrumental errors. Above this comes the isothermal region, where the temperature remains almost unaltered with change of height.

The 34 successful ascents that have been made in England since June last, have in my opinion proved conclusively the existence of the isothermal conditions above some 7½ miles (12,000 metres), although I did not previously doubt its reality. All the high ascents in the daytime or after sunset show this nearly uniform temperature. I think a large inversion may be open to question, certainly it is far more prominent in ascents made in the morning than in those made at sunset.

Nearly all the balloons sent up have drifted to the Eastward, but several that have reached a fair height have fallen within 20 miles or less of their starting-point. It is only in a few instances that the time of flight is known. The heights range to over 12½ miles (20 kilometres), the average being about 7½ miles (12 kilometres), so that bearing in mind the small size of our balloons, and our lack of previous experience, we may, I think, consider the results obtained fairly satisfactory.

II.—RESULTS OF THE BALLOON ASCENTS MADE FROM MANCHESTER, JULY 22-28, 1907.

By J. E. PETAVEL, F.R.S., and W. A. HARWOOD.

For the purposes of this investigation both kites and balloons were used.

1. Observations by Means of Kites.

Kites were sent up, as far as possible daily, from the Glossop Moor Station, between July 16 and 28.

Full information with regard to the results obtained will be found in Tables I. and II.

The weather conditions required for successful work with balloons and with kites are more or less antagonistic. During the International week the weather was not very favourable for kite ascents, the wind on most days being far too light. Nevertheless the kite records give valuable supplementary information, and confirm the results obtained by

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TABLE I.—Kite Observations at Glossop Moor.

Date.		Heights above Mean Sea-Level.							Remarks.
		Ground.	1640 feet.	3280 feet.	4920 feet.	6560 feet.	8200 feet.	10,000 feet.	
July 15, 6.49 p.m. to 8.55 p.m.	Temperature	60°	57°	...	...	...	...	...	One kite, 77 sq. ft. Max. ht. 2325 ft. Min. temp. 53°. Overcast.
	Humidity	89 %	86 %	...	...	...	...	...	
	Wind Dir. and Vel., m. per hr.	E by N	E 34	...	...	...	...	...	
July 16, 10.25 a.m. to 1.20 p.m.	Temperature	68°	65°	58°	59°	...	...	...	One kite. Min. temp. 55° at 4200 ft.
	Humidity	75 %	80 %	90 %	72 %	...	...	...	
	Wind Dir. and Vel., m. per hr.	ENE	E 34	E 38	E 37	...	...	...	
July 16, 4.17 p.m. to 5.38 p.m.	Temperature	71°	66°	59°	...	...	...	...	One kite.
	Humidity	72 %	72 %	85 %	...	...	...	...	
	Wind Dir. and Vel., m. per hr.	E by N	ENE 20?	[E by N 20]?	...	...	...	...	
July 16, 6.44 p.m. to 9.55 p.m.	Temperature	64°	61°	57°	53°	...	...	...	One kite. Cloudless sky.
	Humidity	80 %	85 %	90 %	60 %	...	...	...	
	Wind Dir. and Vel., m. per hr.	NE by E	NE by E	NE by E	NE by E	...	...	...	
July 17, 11.9 a.m. to 1.21 p.m.	Temperature	70°	68°	62°	56°	...	...	...	One kite. Blue sky.
	Humidity	65 %	60 %	70 %	80 %	...	...	...	
	Wind Dir. and Vel., m. per hr.	NE by N	NE 22	NE 24	NE 24	...	...	...	
July 17, 7.15 p.m. to 10 p.m.	Temperature	64°	64°	61°	57°	53°	...	...	Two kites, 154 sq. ft. Max. wire 9000 ft. Max. ht. 7160 ft. Min. temp. 52°. Cloudless sky. Wind vel. record unsatisfactory.
	Humidity	70 %	60 %	20 %	6 %	3 %	...	...	
	Wind Dir. and Vel., m. per hr.	ENE	NNE	NNE	NE by N	NE by N	...	...	
July 18, 4.24 p.m. to 6 p.m.	Temperature	70°	66°	...	...	...	...	...	One kite. Blue sky. Light, variable breeze.
	Humidity	53 %	50 %	...	...	...	...	...	
	Wind Dir. and Vel., m. per hr.	E by S	ESE 21	...	...	...	...	...	

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July 20, 3.52 p.m. to 5.38 p.m.	Temperature	65°	59°	...	...	...	..	...	One kite. Overcast. Light, variable breeze. *N.B.*—Balloon sent up from Manchester at 11 a.m. showed 10 m. per hour. SSW breeze up to 2000 ft., and nearly calm above that level.
	Humidity	80 %	90 %	...	...	...	...	..	
	Wind Dir. and Vel., m. per hr.	E by S	ESE 21	...	...	..	...	...	
July 22, 12 noon to 4 p.m.	Temperature	53°	51°	...	...	...	...	...	Two kites. Light, variable breeze. Apparently calm above 1660 ft.
	Humidity	93 %	93 %	...	...	...	...	...	
	Wind Dir. and Vel., m. per hr.	E by S	E by S 24	...	...	...	...	...	
July 23, 7.30 p.m. to 9 p.m.	Temperature	55°	55°	...	...	...	...	...	One kite. Light, very variable breeze. 8.30 a.m. E by S; 9 a.m. N; 9.55 a.m. S. Upper clouds moving slowly in SSW direction.
	Humidity	80 %	75 %	...	...	...	...	...	
	Wind Dir. and Vel., m. per hr.	E by S	E by S 24	...	...	...	...	...	
July 24, 3.58 p.m. to 4.35 p.m.	Temperature	61°	59°	[53°]	...	...	...	...	One kite. Calm up to 3 p.m. Light breeze later.
	Humidity	70 %	75 %	[80 %]	...	...	...	...	
	Wind Dir. and Vel., m. per hr.	SE	ESE 20	[ESE 24]	..	...	...	...	
July 24, 8 p.m. to 8.30 p.m.	Temperature	52°	54°	...	...	...	...	...	Two kites. Wire 4000 ft. Apparently calm above 1700 ft.
	Humidity	90 %	80 %	...	...	...	...	...	
	Wind Dir. and Vel., m. per hr.	SE by E	ESE 20	...	...	...	...	...	
July 26, 2.18 p.m. to 5.45 p.m.	Temperature	62°	58°	52°	49°	...	...	...	Two kites. Wire 8700 ft. Max. ht. 5710 ft. Min. temp. 48°. Temp. Grad. zero at 4000 ft.
	Humidity	90 %	95 %	100 %	95 %	...	...	...	
	Wind Dir. and Vel., m. per hr.	SW by S	SW by S 23	SW 29	SW by W 30	...	...	...	
July 27, 9.33 a.m. to 4.13 p.m.	Temperature	58°	54°	46°	43°	35°	39°	[46°]	Three kites, 231 sq. ft. Wire 18,800 ft. At 9000 ft. temp. inversion of 11° and humidity zero. All the pens stopped marking until kite had fallen to 8000 ft., when the humidity rapidly rose to 100%. Max. height unknown; probably 10,000 ft.
	Humidity	90 %	95 %	100 %	95 %	95 %	13 %	[0]	
	Wind Dir. and Vel., m. per hr.	W by N	W by N 26	W by N 28	W by N 31	W by N 33	W by N 38	[W by N 39]	
July 27, 5.55 p.m. to 6.10 p.m.	Temperature	63°	58°	...	...	...	...	...	One kite.
	Humidity	71 %	78 %	...	...	...	...	...	
	Wind Dir. and Vel., m. per hr.	W by N	W by N 26	...	...	...	...	...	

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the balloons. Towards the end of the week the wind increased and on the 26th the kite and balloon ascents were both successful. The temperature gradients deduced from these simultaneous records are in good agreement.

On the 27th the wind freshened again. A height of about 10,000 ft. was reached by the kites, but the balloon sent up that day was not recovered and had doubtless drifted out to sea.

2. Balloon Ascents.

Balloons carrying recording instruments were sent up each morning at 11 a.m. between July 22 and 28. The balloons were observed from three trigonometrical stations under the charge of Messrs. W. C. Jenkins, W. Wilson, and W. A. Harwood respectively. A general summary of these observations will be found in Table II.

Indiarubber balloons of the nominal size 2 ft. (600 mm.) diameter were used. These were filled to about 39 ins. (1 metre) diameter. The instruments employed were the 1 oz. Dines meteorographs as described in *Symons's Meteorological Magazine*, vol. 41, p. 102.

The instruments, together with instructions to the finder, were attached to a small silk parachute (11 ins. square) suspended some 6 ft. below the balloon.

In a normal ascent the apparatus should reach the ground some two or three hours after the start. The balloons are filled to give a lifting power considerably in excess of the weight carried, and should rise rapidly until they expand to their maximum capacity and burst.

The size of the parachute is adjusted so that the rate of fall may be as rapid as is consistent with the safety of the instrument. If the ascent be prolonged owing either to insufficient initial lifting power, or to a slight leak of the hydrogen, there is a high probability of the balloon drifting out to sea; further, the vertical motion being in this case slow, the ventilation of the instrument suffers and the record is unreliable.

During the International week a balloon was filled each morning at 10.30, and carefully inspected with a view to detecting and closing the small holes which are apt to develop in the thin rubber. It was carried to the observatory roof and the instrument was attached, the spare lifting power being at the same time determined.

A signal was then sent to the two distant trigonometrical stations, and the balloon was liberated. Trigonometrical observations were made every ten seconds. Owing to the hazy weather the balloons were usually lost to view in a very short time, and the trigonometrical observations were therefore not very satisfactory.

Discussion of Results Obtained.—We now come to the consideration of the five records which have been recovered. In those of July 23, 24, and 25, the upward and downward traces coincide. In the record of July 26, there exists a divergence averaging two or three degrees.

Whereas the first three balloons rose rapidly to a very considerable height and burst, that of the 26th seems to have developed a slight leak, and it was the gradual escape of gas which finally brought it to the ground. The slow vertical motion and consequent bad ventilation sufficiently account for the divergence of the two traces. None the less,

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TABLE II.—Balloon Ascents.

Date.	No.	Time.	Lift.	Average Vertical Velocity.	Barometer.	Temperature °F.	Direction and Velocity of Wind. — Ground.	— 1640 ft.	3280 ft.	Remarks.
					ins.	°				
July 22 .	12	11 a.m.	about 5 oz.	...	29·94	57	S83°E 12	...	...	No observations from two of stations on account of mist. Instrument not returned.
,, 23[1] .	14	,,	...	590 ft. per min.	29·91	60	S20°E 4	...	...	Fell S by E 11 miles, near Macclesfield. Height, 13·3 miles. Minimum temperature, −54°·4 at 8·7 miles.
,, 24[1] .	15	,,	9 oz.	578 ft. per min.	29·94	59	S25°E 6	S82°E 5	S72°E 4	Fell N84°E 20 miles. Maximum height, 13 miles. Minimum temperature, −59°·8 at 6·7 miles.
,, 25[1] .	16	,,	11 oz.	688 ft. per min.	29·93	55	S50°E 10	S24°E 7	S80°E 3	Fell near Leeds, 35 miles NE by E at 1·15 p.m. Average horizontal velocity, 16 miles per hour. Maximum height, 13·3 miles. Minimum temperature, −39°·1 at 6·8 miles.
,, 26[1] .	13	,,	12 oz.	812 ft. per min.	29·89	66	S14°E 3	S19°W 9	...	Fell 70 miles E by S, near Lincoln. Average horizontal velocity about 28 miles per hour. Maximum height, 6·7 miles. Minimum temperature, −31·9 at 6·7 miles.
,, 27 .	14	,,	...	...	29·85	64	N86°W 12	N78°W 22	...	Instrument not returned.
,, 28[1] .	21	,,	7 oz.	590 ft. per min.	29·94	64	S 11	S8°W 11	S13°E 10	Fell near Huddersfield. Followed to height of 8400 ft. Wind—6500 ft., S60°W 14; 8000 ft., S66°W 20.

[1] These instruments have been returned.

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as mentioned above, the temperature gradient agrees well with that obtained from a simultaneous kite ascent and the error cannot therefore be very large.

A few experiments were made with a view to estimating the probable

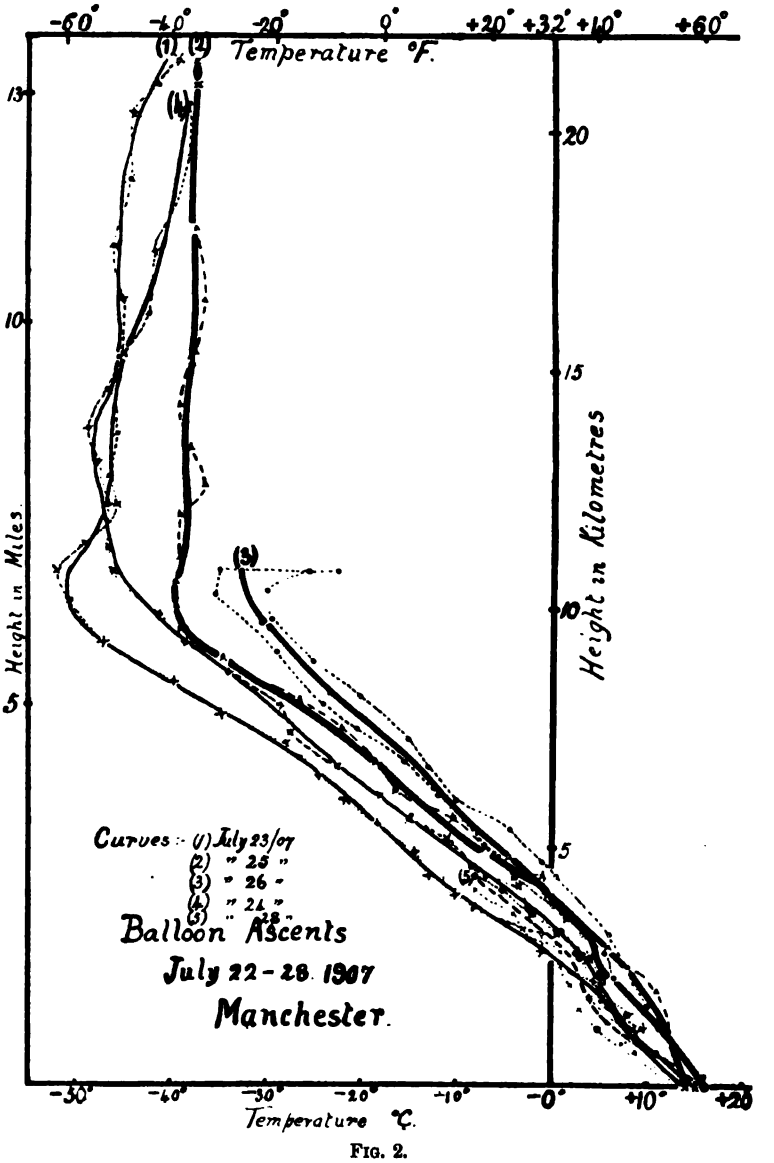


FIG. 2.

error introduced by unsatisfactory ventilation. Two instruments were compared. The one was exposed to the full sunshine and screened from the wind, the other was protected from all radiation. The mean difference between the temperatures indicated was about 5°·5.

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Now under the actual conditions of the ascent the total radiation incident on the surface of the case when the balloon is at its maximum height is much greater than under the circumstances described; but on the other hand the balloon is never quite at rest, and the instrument is in consequence always ventilated to some extent.

Continental observers have pointed out that in some instances solar radiation produced an error in the temperature of as much as 50° when the instrument was badly ventilated. From what has been said above it seems extremely unlikely that an error of such magnitude could occur in the case of the Dines meteorograph. The shape of this instrument—an open-ended cylinder—is exceptionally favourable to good ventilation, and the polished aluminium exterior reduces the heat absorption to a minimum.

The difficulty with regard to the height determinations lies in the uncertainty of the zero of the trace and in slight irregularities of the calibration. From the measurement of the traces we obtain directly the amount by which the atmospheric pressure has fallen during the ascent. The difference between this and the barometric reading at the ground level gives us the residual pressure from which the height is computed. The pressure at the highest level is the difference between two large quantities and is consequently subject to a relatively considerable error. Further, at great altitudes the rate of change of pressure with height is very small. It follows, therefore, that the determination of the maximum height is always somewhat uncertain.

Curves giving the results of the five ascents are shown in the accompanying diagram (Fig. 2).

The ascents confirm the interesting theory put forward by Teisserenc de Bort[1] with regard to the existence of a nearly isothermal layer above some 7 miles.

Between the ground-level and a height of about 5 miles the temperature falls continuously. The average gradients over this range varied during the week between 0°·28 and 0°·33 per 100 ft. (0°·5 and 0°·6 C. per 100 metres). Above 7 miles all our curves show a more or less marked temperature inversion.

To what extent these and the other features of the curves may depend on local circumstances or even on instrumental errors can only be determined when the results obtained at the other stations have been worked out.

Pending the publication of the complete observations it is of course useless to attempt any general discussion of the subject.

[1] *Comptes Rendus*, vol. 134, pp. 987-1000, April 1902. Vol. 138, pp. 42-45, Jan. 1904. Vol. 145, pp. 149-152, July 1907, etc.

III.—BALLOON EXPERIMENTS IN DUBLIN, JULY 22-27, 1907.

By Prof. W. E. THRIFT, M.A., Trinity College, Dublin.

It was proposed to observe the balloons from Trinity College, Dunsink Observatory, and Mountjoy Square, the observations made at the third station being intended to check those made at the others.

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Unfortunately the weather throughout the week could hardly have been worse for the purpose, as it was almost invariably thick and cloudy. There was a slight improvement on Friday afternoon in the suburbs, so Ashtown Racecourse was substituted for the city stations. It is near Dunsink, between Dunsink and the Phœnix Park, which lies to the west of the city. On Friday two stations were chosen on a straight stretch of the racecourse which runs nearly east and west. These stations were about five-eighths of a mile apart; the west one being in full view of Dunsink Observatory, distant about half a mile from it. However, probably because their telescope could not be depressed below an altitude of a few degrees, and because the Observatory is on a hill, the Dunsink observers did not get in view in their telescope the balloons sent up from Ashtown, so that observations on them were only taken from the Ashtown stations. On Saturday afternoon, July 27, owing to scarcity of observers, only one station was used at Ashtown. Balloons were sent up both from Ashtown and from Dunsink Observatory: observations on the latter were taken from both stations.

Two balloons a day, at least, were sent up, despite the fact that little was to be expected from the direct observation of them because of the thickness of the atmosphere, as it was hoped that information might be gained from their ultimate destination, which was regarded as the primary object of the experiments. Of the earlier ones, several had obviously insufficient lifting power, even though I had considerably exceeded the suggested degree of inflation. I was at first afraid to inflate them more lest they should burst before reaching any considerable height. Direct experiment on one balloon showed what degree of expansion that particular kind of balloon was capable of, and it was easy then to calculate, approximately at any rate, what inflation was permissible with a given rise in view. It will be noticed that with one exception all the balloons, of the finding of which I have been notified, were found near Dublin, and that they were the ones with very little lifting power. In fact the condensation of moisture on them was probably sufficient to bring them down. The exception had good lifting power and crossed the Channel, falling in Wales. The direction of the upper current was therefore, on this occasion, North-West, though that of the lower was South-East. Most of the other balloons probably fell in the Channel.

I think that possibly interesting information may be obtained from experiments 15, 16, and 19, with regard to the rate of ascent question.

I can determine the positions of the various stations, from observations taken at them, to a fair degree of accuracy, if they are required.

The balloons were generally lost sight of owing to their disappearance in clouds.

Professor Whittaker, his assistant Mr. Martin, Mr. G. T. M'Caw, of the Geodetic Survey, N.E. Rhodesia, my assistants Mr. Jackson and Mr. Cotter, and three of our students, Mr. Poole, Mr. Hill, and Mr. Panton, took important parts in the carrying out of the experiments.

I think the method adopted quite satisfactory and capable of successful application if large balloons are used, and proper arrangements made with regard to stations and observing instruments. I found the best way of conducting the observations was to have one observer at the observing telescope, and two others at the measuring circles. The former kept the

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Balloon Observations made at Dublin.

No. of Experiment.	July.	Time.	Height of Barometer uncorrected.	Temperature Dry Bulb.	Temperature Wet Bulb.	Wind Lower.	Wind Higher.	Weather.	No. of Letter.	Description of Balloon, unextended diameter. ins.	Inflated Circumference.	Weight of Balloon in grams.	Lifting Power in grams.	Observations taken.	Place found.	Where released.	Time seen at release station.
		hrs. min. sec.	ins.	°	°						ins.						min. sec.
1	22	9 3 30 A.	30·012	59·9	58·1	NE	...	Dark. Sky overcast with clouds. Mist at intervals	1	7⅛	44½	13·9	14·2	One at T.C.D. station (A)	?	Park, T.C.D.	1
2	23	9 10 0 A.	29·954	56·0	55·5	ENE	...	Raining slightly	2	6½	38	13·9	2·0	...	Holywood Rath, Co. Dublin	Park, T.C.D.	1 55[1]
3		Tested balloon similar to above by inflation with bellows. It burst at							69 ins,	circumference.							
4		Strip of rubber 1 in. wide broke under pull of 1500 grams.															
5		Inflated balloon, as in No. 1, lost 1 gram lifting power in 33 minutes.															
6		Inflated balloon, as in No. 1, released in room did not fall for 7 hours.															
7	23	5 0 0 P.	29·978	...	...	E	...	Dull. Cloudy	3	7	44	13·7	9·8	17 at T.C.D. station (B)	?	Park, T.C.D.	7 45
8	24	10 0 0 A.	30·006	58·1	55·7	E	...	Dull. Cloudy	4	7	41	14·0	6·5	11 at T.C.D. station (C)	?	Park, T.C.D.	3 40
9	24	4 16 0 P.	30·026	...	...	E	...	Dull. Cloudy	5	4½	31½	7·0	3·0	...	Clondalkin, Co. Dublin	Park, T.C.D.	6
10	25	9 30 0 A.	29·998	59·0	55·2	ESE some low smoke from ENE	...	Bright through clouds. No clear sky	6	7	41	13·5	7·0	Several at T.C.D. station (D)	?	Park, T.C.D.	4 58
11	25	10 16 30 A.	...	...	...	...	...	...	7	Large Fire Balloon	...	...	...	Several at T.C.D. One at Mountjoy Sq. (E)	Tallaght, Co. Dublin	Phys. Lab., T.C.D.	8 30
12	25	6 8 0 P.	29·991	...	...	SE	NW	Cirrus clouds. High with some low	8	24	(?)110	331·8	95·2	One at Mountjoy Sq. Several at T.C.D. (F)	Llandilafawr, Breconshire	Park, T.C.D.	13 15
13	26	9 5 0 A.	29·890	64·2	60·4	SE	...	...	9	11	68	87·9	1·0	At Mountjoy Sq. and at T.C.D. (G)	Drumcondra, Co. Dublin	Park, T.C.D.	7 15[2]
14	26	11 0 17 A.	...	...	...	...	...	...	10	13	84	86·7	93·2	At T.C.D. (H)	?	Park, T.C.D.	3 43
15	26	12 0 0	...	...	...	...	...	...	...	6¾	62	29·2	42·7	Two stations T.C.D. (I)	...	Park, T.C.D.	3 25[3]
16	26	5 46 0 P.	...	...	...	NW	...	Fair, but clouds present	11	6¾	62	29·2	42·6	Two stations Ashtown (J)	?	Ashtown, W. station	8 47
17	27	9 0 0 A.	29·968	62·1	57·0	SW	...	Cloudy . .	12	6¾	53	29·1	15·2	At T.C.D. (K)	?	Park, T.C.D.	4 12
18	27	4 58 ·7 P.	...	...	...	WSW	...	Fair. Few clouds	13	12	77	87·5	46·7	At Ashtown (L)	?	Ashtown .	9 43
19	27	5 14 0 P.	...	...	...	...	...	...	14	6¾	60	29·2	36·2	At Dunsink & Ashtown (M)	?	Dunsink Observatory	19 30

[1] Inflation advised, but obviously insufficient. Feared bursting on rising, therefore tried following experiments.
[2] Stopped inflation because expanded unevenly, developing a very thin spot. Only sent up because of arrangement as to time with other stations.
[3] This balloon was sent up in order that direct observations on its rate of ascent might be made from two stations.

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balloon always in view; on bringing it to the intersection of cross wires, he called to the other observers who noted the time and the readings of the horizontal and vertical circles; they generally had time to take their readings before the observer at the telescope was obliged to move the telescope in order to prevent the balloon going out of the field of view. In this way the balloon could be followed till it appeared as a very small speck in the telescope—so small that it would have been quite impossible to find it again, if once lost sight of by the observer.

The Dispersal of Fog.

Some time ago Dr. Shaw, the Director of the Meteorological Office, at the invitation of the London County Council, consented to examine and report upon the proposals of Signor Demetrius Maggiora "to prevent the formation of fog, or to disperse it in case it is already formed, and also to disperse and destroy all clouds, and to prevent rain, hailstorms, lightning, and thunder."

In his report to the Public Control Committee Dr. Shaw stated:—

"The apparatus which Signor Maggiora now offers for removing London fog is apparently on similar lines to that supplied in Italy for dispersing hail-storms. From the scientific point of view hail affords a much more specious opportunity for human interference than fog. The atmosphere is then in a state of great commotion preceded by abnormally unstable conditions. A London fog is incidental to conditions of unusual stability, and Signor Maggiora's memorandum suggests no physical process which could produce any effect in accordance with the known physical properties of the atmosphere.

"It may be remarked that the weight of a cubic mile of air is about five million tons, and consequently the weight of fog-laden air, in the case of a fog a mile thick extending over the district of greater London alone, is 3000 million tons. It is obviously useless to attempt the motion of so great a mass by mechanical action. . . .

"I may sum up by saying that the claim to prevent or disperse fog is entirely unsupported by any evidence. The claim to prevent rain is opposed by the more frequent claim of similar processes to produce rain in countries which suffer from drought, and the claim to affect hail-storms (which is associated with that regarding thunder and lightning) is not allowed by the scientific experts of Austria and Italy who have conducted special investigations on the subject for their respective Governments."

Having regard to the terms of Dr. Shaw's report, the Committee made the following recommendation to the London County Council, which was agreed to:—"That the Main Drainage Committee be authorised to allow Signor D. Maggiora the use of a site, on land held for main drainage purposes, in order to enable him to conduct experiments with his apparatus for the prevention and dispersion of fog, and that the grant of any such facilities to Signor Maggiora shall be made on the distinct understanding that the experiments are not being carried out under the direction of the Council, and that the name of the Council shall not be used in any way in connection with any application for financial aid for working the invention."

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DISCUSSION OF THE METEOROLOGICAL OBSERVATIONS AT THE BRITISH KITE STATIONS, SESSION 1906-1907.

By MARGARET WHITE, T. V. PRING, AND J. E. PETAVEL, F.R.S.

[Read November 20, 1907.]

Introduction.

Investigations of the upper air are carried out at four British Stations by means of kites and balloons.

These stations are—

1. Pyrton Hill, near Watlington, Oxon, 500 ft. above sea-level.
2. Ditcham Park, near Petersfield, Hampshire, 400 ft.
3. Brighton, Sussex, 380 ft.
4. Glossop Moor, Peak District, Derbyshire, 1100 ft.

The work is under the general direction of Mr. W. H. Dines, F.R.S., who has devised most of the special apparatus in use.

The present paper consists of an analysis of the records obtained during the past session.

The kites carry meteorographs which give a continuous record of temperature, wind velocity, humidity, and height. Some 5000 readings have been obtained from these records and form the principal basis of the following conclusions.

Temperature Gradients.

Under ordinary circumstances the atmospheric temperature decreases continually with increasing height. The rate of fall is, in the daytime, very rapid close to the ground and diminishes at higher levels.

The average temperature gradient calculated from the data published during the present session is given in the following table :—

TABLE I.—Temperature Gradients (Degrees Fahr. per 100 feet) in Various Parts of England. Average Values, Session 1906-1907.

Place	Ground—1640 ft.	1640-3280 ft.	3280-4920 ft.	4920-6560 ft.
Glossop Moor . . .	0°·68	0°·50	0°·34	0°·18
Brighton	0·44	0·30	...	...
Ditcham Park . . .	0·58	0·41	...	...
Oxshott and Pyrton Hill .	0·43	0·41	0·36	...

The decrease of temperature is somewhat more rapid at Glossop Moor and Ditcham Park than in the case of the other two stations. The average temperature gradient for all stations works out at 0°·50 per 100 ft. (0°·92 C. per 100 metres) between the ground-level and 1640 ft. (500 metres), 0°·42 (0°·76 C.) between 1640 and 3280 ft. (500 and 1000 m.), and 0°·34 (0°·61 C.) for the next 1640 ft. (500 m.).

In Fig. 1 the average temperature height curves for the various stations are given. For the purpose of comparison curves embodying the

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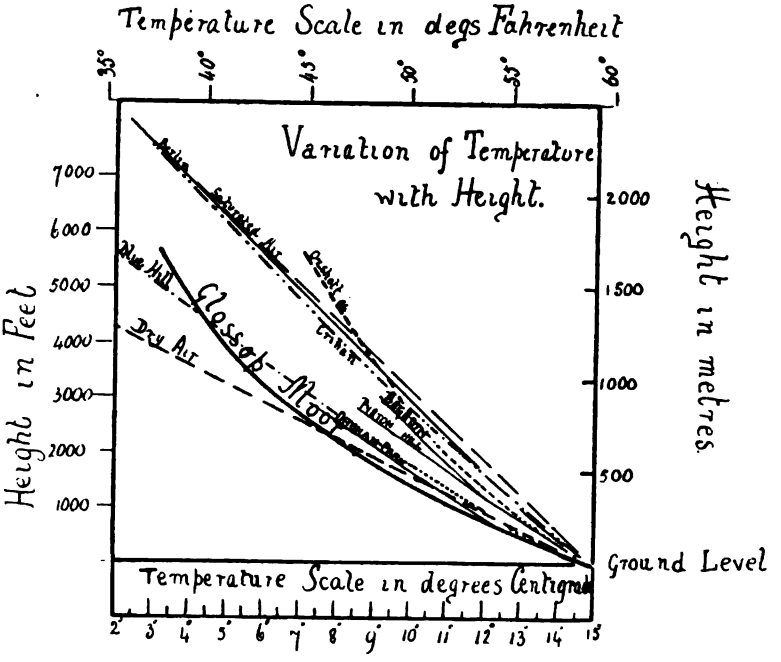


FIG. 1.

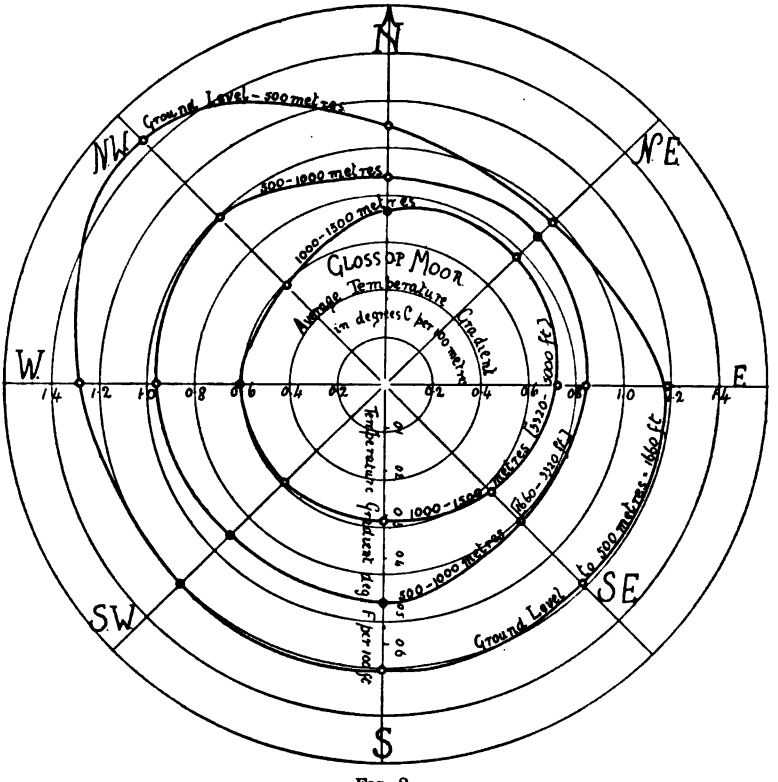


FIG. 2.

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results obtained at Blue Hill,[1] Berlin,[2] Oxshott, and Crinan during previous years are inserted.[3]

The theoretical fall of temperature due to the adiabatic expansion of dry and also of saturated air will be found on this diagram.

The Berlin, Crinan, and Oxshott curves agree closely with the calculated gradient for saturated air, whereas the Blue Hill and Glossop Moor curves lie closer to the dry air values.

Let us now consider what factors might *a priori* be expected to cause a departure from the above-stated average conditions.

Firstly, the temperature gradient varies with the direction of the wind. At Glossop Moor it is largest for a North-west wind, as will be seen in the polar diagram (Fig. 2).

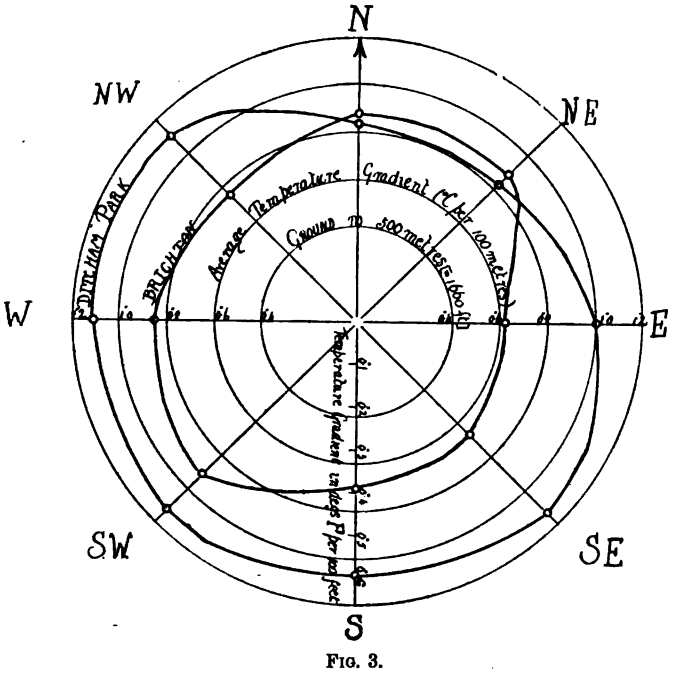


FIG. 3.

The distribution at Brighton and Ditcham Park is shown in Fig. 3. At Oxshott and Pyrton Hill both the change of gradient with height, and the variation with wind direction, as calculated from this session's observations, are very small.

Numerous observers have noticed that in a general way the temperature gradient is highest on fine cloudless days, and lowest when the sky is overcast.

This led us to calculate the average temperature gradient at Glossop for a high and for a low barometric pressure, with the following result:—

[1] See Dines, *Proc. Roy. Soc.* vol. lxxvii. p. 443.

[2] *Met. Zeit.*, 1904, p. 459.

[3] See also for Paris, St. Louis, Blue Hill, Berlin, and Moscow, *Beitr. z. Phys. d. freien Atmos.*, 1906, vol. ii. p. 40.

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TABLE II.—Average Temperature Gradient for High and Low Barometric Pressures (Degrees Fahr. per 100 feet).

	Ground-1640 ft.	1640-3280 ft.	3280-4920 ft.
Barometer above 30 inches . .	0°64	0°41	0°45
,, below 30 inches . .	0·59	0·41	0·31

The difference is small but seems to bear out the statement. If, however, we take as our criterion the actual percentage of clouded sky during the ascent we obtain a much more definite result.

TABLE III.—Temperature Gradient at Glossop on Cloudless and on Overcast Days (Degrees Fahr. per 100 feet).

	Cloudless or almost cloudless sky.	Sky partly clouded.	Sky entirely overcast.
Ground-1640 ft.	0°91	0°84	0°51
1640-3280 ft.	0·60	0·55	0·39
3280-4920 ft.	0·33 (?)	0·28	0·27

With a cloudless sky, therefore, the average temperature gradient is always large.

This effect is doubtless due to the difference between the adiabatic expansion of dry, saturated, and partly saturated air; and this conclusion is borne out by a comparison between the percentage of humidity corresponding to the average of the highest and lowest temperature gradients.

TABLE IV.—Temperature Gradient and Humidity, Glossop, 1906-7 (Degrees Fahr. per 100 feet).

	Gradient.	Corresponding Average Humidity. %
Ground-1640 ft. . . .	0°99	77
	0·45	91
1640-3280 ft.	0·63	82
	0·36	94
3280-4920 ft.	0·46	79
	0·17	94

The observations were also analysed in order to estimate the connection between the wind velocity and the temperature gradient. Taking for each height the average, firstly of the lowest and then of the highest temperature gradients, we obtain the following result:—

TABLE V.—Wind Velocity and Temperature Gradients.

Temperature Gradient in degrees Fahr. per 100 ft.; Wind Velocity in miles per hour.

Place.	Ground-1640 ft.		1640-3280		3280-4920	
	Temp. Gradient.	Wind Velocity.	Temp. Gradient.	Wind Velocity.	Temp. Gradient.	Wind Velocity.
Glossop Moor . .	0°45	17	0°36	28	0°17	35
	0·99	15	0·63	24	0·46	31
Ditcham Park . .	0·38	30	0·35	30	...	...
	0·73	26	0·52	28	...	...
Brighton . . .	0·13	20	0·09	29	...	...
	0·71	22	0·49	24	...	...
Oxshott . . .	0·22	22	0·12	28	...	...
	0·65	19	0·54	34	...	...

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There is, it appears, little doubt that a strong wind and a low temperature gradient usually co-exist.

The results obtained near Paris, Blue Hill, and Berlin, show a considerable variation of temperature gradient from summer to winter;[1] this effect exists in England but it is much less marked.

TABLE VI.—AVERAGE TEMPERATURE GRADIENT IN SUMMER AND WINTER (Degrees Fahr. per 100 feet).

	Ground-1640 ft.	1640-3280.	3280-4920.
Average for England.			
Summer	0°·59	0°·47	0°·38
Winter	0·46	0·38	0·24
Average for Berlin.			
Summer	0·60	0·38	0·36
Winter	0·18	0·15	0·16

The result of this relatively slight alteration of the gradient with the season of the year is to render the curves of temperature nearly parallel at all heights, as, for instance, is shown in the case of Glossop in Fig. 4.

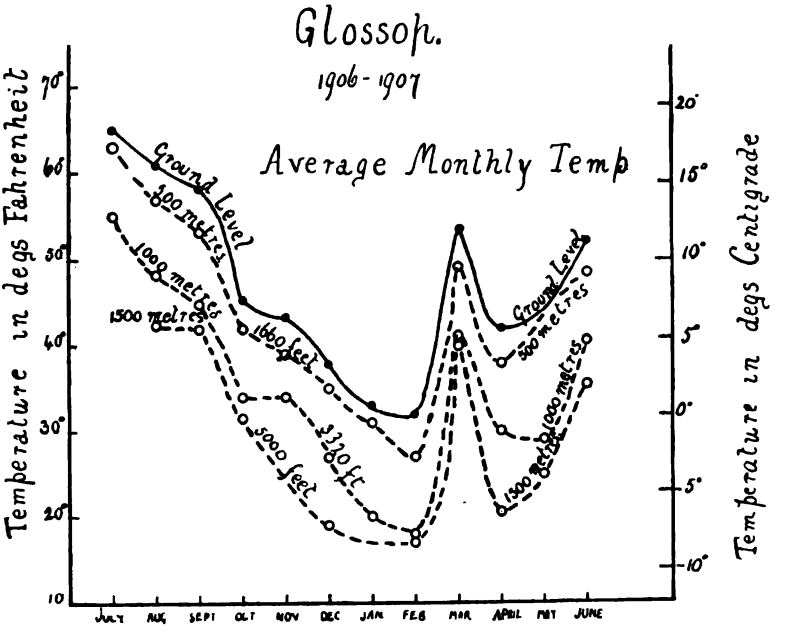


FIG. 4.

Wind Velocities.

A serious defect of the investigation by means of kites is that the conditions under which observations can be taken are limited; a calm or, on the other hand, a very stormy day rendering a successful ascent impossible.

To obviate this defect it is hoped in subsequent years to provide for

[1] See *Beitr. z. Phys. d. freien Atmos.*, 1906, vol. ii. p. 35.

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the use of balloons on calm days, while the recent installation at Glossop Moor of new machinery, purchased with funds awarded by the Government Grant Committee of the Royal Society, will, it is hoped, considerably increase the chances of a satisfactory ascent in very high winds.

In Table VII. the average wind velocities at various heights have been worked out from the results obtained at each of the kite stations.

TABLE VII.—Average Wind Velocities (Miles per hour).

Place.	Ground.	1640 ft.	3280 ft.	4920 ft.
Glossop Moor	13·0[1]	26·1	30·2	33·3
Oxshott and Pyrton Hill . .	13·0	30·0	31·8	36·7
Brighton	16·1[1]	26·6	28·5	...
Ditcham Park	24·7	29·5	31·2	37·5 (?)

[1] Estimated.

The average wind velocity at each height is therefore nearly the same at all stations. It has been pointed out that these numbers do not include all possible weather conditions; but as the maxima and minima wind velocities happen to be both excluded by experimental difficulties, the error is to a certain extent compensated. The rate of increase is, however, probably somewhat exaggerated, owing to the fact that the higher altitudes are attained only when the upper wind is of considerable strength.

The average wind velocity increases with height very rapidly for the first 330 ft. and more slowly at higher levels.

At the Blue Hill Observatory the increase in velocity with height is 0·6 mile per hour in summer, and 2·1 miles per hour in winter for each 330 ft. rise.

In England, near to the ground level, a similar change occurs, the winds in winter increasing twice as rapidly as in summer. At heights above 1640 ft. the gradient still alters with the season. The variation, however, is in the reverse direction, the increase in winter being 0·9 mile per hour per 330 ft., falling in the summer months to 0·6 mile per hour.

It has been suggested by Clayton and by Egnell[1] that the wind velocity at any altitude is inversely proportional to the density of the atmosphere at that altitude; that is to say, the mass of air passing a given point in a given time is constant for all altitudes, or, expressed algebraically,

$$Vd = \text{constant}$$

where V is the wind velocity and d the density of the atmosphere.

The law applies well for high levels, but at the moderate heights reached by kites the increase is rapid, and follows more closely the inverse square of the density.

We now come to the question of the alteration of wind direction with height. As is well known from the study of the motion of clouds, and from the data obtained by means of balloons, the direction of the wind alters at high levels, rotating in a clockwise direction; for instance, a South wind tends to become more Westerly.

In individual experiments the amount, and even the direction of the rotation, differ widely. Taking, however, averages from the 600

[1] *Comptes Rendus*, 1903, vol. cxxxvi. pp. 358-361.

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observations of wind direction, which are available for the present session (balloon ascents included), we obtain a consistent result, showing that up to 8200 ft. the angle between the wind at the ground level and the upper wind is nearly proportional to the height.

Height.	Total angle of rotation.
Ground to 1640 ft.	11°
,, 3280 ,,	18°
,, 4920 ,,	20°
,, 6600 ,,	30°
,, 8200 ,,	40°

Previous investigations have shown that both under cyclonic and anticyclonic conditions the change of direction is greatest in the case of a Southerly wind. Taking from our observations the average rotation for such winds we obtain angles of 13°, 35°, and 67° between the wind at the ground level, and at 1640, 4980, and 8200 ft. respectively, *i.e.*, a rotation nearly 50 per cent. above the general average.

The investigation of the relation between wind velocity and barometric gradient may not seem at first sight to offer serious difficulties. In

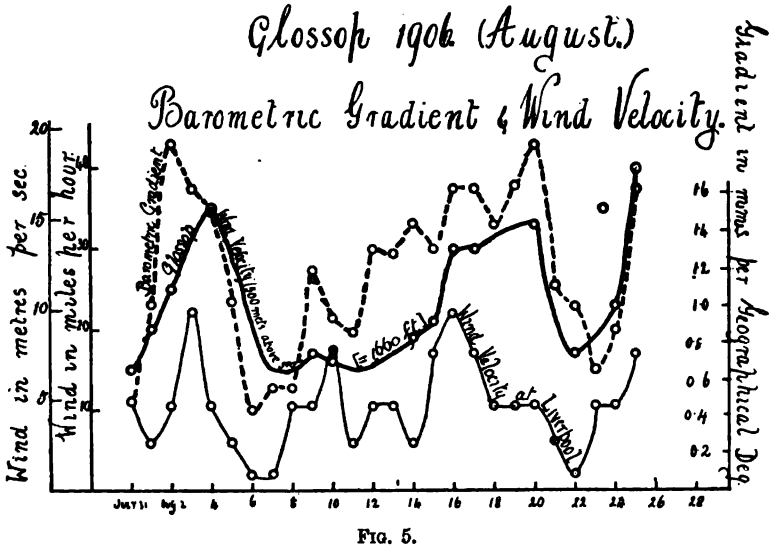


FIG. 5.

Fig. 5 the gradients and resulting wind velocities, as measured at Glossop during August 1906, are plotted, and the synchronous rise and fall of the curves is at once apparent. It is equally evident that the wind velocity cannot be expressed as a simple function of the gradient. Theoretical considerations confirm this view. The wind velocity depends, not merely on the absolute value of the gradient, but on the angle which the wind forms with the direction of the gradient, on the curvature of the path, and doubtless also on the wind direction, season of the year, and other factors.

A preliminary study of the question showed that the data available were too incomplete to form the basis of reliable conclusions.

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The exact gradient at the time at which the observations are taken cannot be obtained with accuracy; the general disposition of the isobars over the country is recorded morning and evening by the Meteorological Office, but it is only by interpolation that the gradient at any other time of day can be determined. Again, small local variations in barometric pressure cannot be obtained from the weather charts, but have probably an important effect on the prevailing wind.

It would be useless to give a further account of this incomplete and therefore unsatisfactory part of our work.

During the coming year it is hoped to arrange for barometric observations to be made, during the kite ascents, at various places in the neighbourhood of the Glossop Station, with a view to the further study of this question.

APPENDIX.

The values given in Tables I.–VII. are reproduced in the Centigrade and Metric scales in the following Tables for the use of Continental observers :—

TABLE I.—Temperature Gradients (Degrees Centigrade per 100 metres) in various Parts of England. Average Values for the Session 1906-1907.

Place	Ground level-500 metres.	500-1000 metres.	1000-1500 metres.	1500-2000 metres.
Glossop Moor . . .	1·24°	0·91°	0·61°	0·33° (?)
Brighton	0·81	0·54	...	...
Ditcham Park . . .	1·05	0·75	...	...
Oxshott and Pyrton Hill .	0·78	0·75	...	...

TABLE II.—Average Temperature Gradient for High and Low Barometric Pressure (Degrees Centigrade for 100 metres).

	Ground-500 metres.	500-1000 metres.	1000-1500 metres.
Barometer above 762 mms. . .	1·17°	0·75°	0·81°
Barometer below 762 mms. . .	1·08	0·75	0·56

TABLE III.—Temperature Gradient at Glossop on Cloudless and on Overcast Days (Degrees Centigrade per 100 metres).

	Cloudless or almost cloudless sky.	Sky partly clouded.	Sky entirely overcast.
Ground-500 metres . .	1·66°	1·53°	0·93°
500-1000 metres . .	1·09	1·00	0·72
1000-1500 metres . .	0·60 (?)	0·51	0·49

TABLE IV.—Temperature Gradient and Humidity, Glossop, 1906-7 (Degrees Centigrade per 100 metres).

	Gradient.	Corresponding Average Humidity.
		%
Ground-500 metres . . .	1·80°	77
	0·82	91
500-1000 metres . . .	1·14	82
	0·65	94
1000-1500 metres . . .	0·83	79
	0·31	94

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TABLE V.—Wind Velocity and Temperature Gradients.

Temperature Gradient in degrees Centigrade per 100 metres; Wind Velocity in metres per second.

Place.	Ground-500 metres.		500-1000 metres.		1000-1500 metres.	
	Temp. Gradient.	Wind Velocity.	Temp. Gradient.	Wind Velocity.	Temp. Gradient.	Wind Velocity.
	°	m.p.s.	°	m.p.s.	°	m.p.s.
Glossop . .	0·82	7·6	0·66	12·5	0·31	15·6
	1·805	6·7	1·13	10·7	0·84	13·8
Ditcham Park .	0·695	13·3	0·645	13·1	...	...
	1·325	11·6	0·943	12·5	...	...
Brighton . .	0·232	8·9	0·168	13·1	...	...
	1·297	9·6	0·890	10·7	...	...
Oxshott . .	0·394	9·8	0·186	12·3	...	...
	1·188	8·3	0·980	15	...	...

TABLE VI.—Average Temperature Gradient in Summer and Winter (Degrees Centigrade per 100 metres).

	Ground-500 metres.	500-1000 metres.	1000-1500 metres.
Average for England.	°	°	°
Summer . . .	1·08	0·86	0·70
Winter	0·84	0·69	0·43
Average for Berlin.			
Summer . . .	1·09	0·69	0·65
Winter	0·24	0·27	0·30

TABLE VII.—Average Wind Velocities (Metres per second).

Place.	Ground.	500 metres.	1000 metres.	1500 metres.
Glossop Moor . .	5·8[1]	11·6	13·5	14·9
Oxshott and Pyrton Hill	5·8	13·3	14·2	16·4
Brighton . . .	7·2[1]	11·8	12·7	...
Ditcham Park . .	11·0	13·1	13·9	16·7 (?)

[1] Estimated.

DISCUSSION.

Mr. W. Marriott said that the Kite Committee had considered it desirable that balloon observations should be taken in Ireland. Sir John Moore had suggested that they should apply to Prof. W. E. Thrift of Trinity College, Dublin; and he, with the assistance of the Astronomer-Royal for Ireland and other gentlemen, had entered into the matter very heartily. The Kite Committee considered it not desirable to send up any meteorographs, as Dublin was so close to the sea. A number of pilot balloons were used, and arrangements were made for having two or three observers with theodolites, to get the altitude and rate of travel of the balloons. The great difficulty experienced was with the weather. The sky was covered with low cloud, in which the balloons were lost in less than a minute. Only one of the balloons had passed over the sea, and that fell in Wales. Most of the balloons fell near Dublin, and did not attain any great altitude. A great deal of interest had been aroused, and much attention given to the subject in Ireland.

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Mr. C. J. P. CAVE said that he had sent up six balloons in July, of which four had been returned. He showed the temperature and height curves on a lantern slide. Some of the balloons sent up in the daytime showed an undue rise of temperature at the highest points reached. The balloon sent up on July 23 gave higher temperatures than usual, due perhaps to solar radiation, as the balloon was probably not ascending fast; it was leaking and was found intact next day floating in the Channel. A balloon sent up on the evening of July 24 went up to 52,500 feet (16,000 metres), and was watched with one theodolite for two hours. The sun set on the balloon 22 minutes later than it set on the ground. July 25 was the only day on which an ascent was made with an instrument other than that of Mr. Dines', one of M. Teisserenc de Bort's meteorographs being used. The balloon of July 27 was the only one sent up at night; it reached a height of 28,000 ft. (8500 metres), and the decrease of temperature was rather greater than in the other cases. He was very grateful to Mr. Dines for the instrument he had designed, as those used on the Continent were heavier and much more expensive. In the International ascents England headed the list for height with two ascents at Manchester of 69,000 feet (21,000 metres), and out of nine ascents of over 65,000 feet (20,000 metres) four took place in England.

Captain C. H. LEY said that his observations had been chiefly carried on with pilot balloons, of which he had sent up more than thirty. He had used a method different from the other methods, consisting of measuring the diameter of the balloon by wires in the diaphragm of a theodolite, and from that getting the range of the balloon. Observations of the altitude determined the vertical height and the horizontal distance. Most of the results had been plotted, and he was submitting a general report on them. They were interesting chiefly in the matter of velocities. They showed no steady velocity, and the average over a long run could give only fair results, but there were considerable and sharp variations. His results agreed generally with the few returns given by Mr. Dines' instruments of the temperature variations. When the velocity was fast the temperature gradient was slow.

Dr. W. N. SHAW remarked that it was not long ago since the investigation of the upper air had been put aside, on the ground that it was impossible in this country, and it was extremely gratifying to find, within a few years, that the upper air had been investigated by the ascent of about twenty-five balloons during a single week. A new system of observations had also been introduced by the method of pilot balloons and their examination by theodolites. Captain Ley had used this method with remarkable effect, and it promised to form the subject of an interesting paper at a later date. They had heard two sets of papers, the first connected with the international ascents in the last week of July, and the second concerning the general results of kite and balloon observations, comparing the results obtained at different stations in the British Isles during the year 1906-7. It was rarely that any one was found to discuss the observations made by other people, and they had to thank Mr. Petavel for so doing. Mr. Petavel had dealt with the results of the different kite stations by the method of mean values. When considering the observations returned to the Meteorological Office with Mr. Gold, he had thought it desirable to go behind this method, and to endeavour to make some pictorial representation of the results of the kite observations, in which the classification of the observations according to frequency was represented. The diagrams he had had prepared were included in a paper read before the Aeronautical Society last December. He showed four slides, which gave the results at Oxshott in the form of differences at successive steps of 500 metres (1640 feet) from the values at 500 metres above sea-level. Dr. Shaw then called attention to the confirmation which the recent experiments afforded to the existence of the stratosphere, a layer of air

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above which there would only be a slight variation of temperature. This isothermal layer was found at about 10 kilometres (6·2 miles), and its existence was clearly proved by many ascents. The curves compared satisfactorily with the best of those obtained on the Continent. As to the origin of this layer there were different suggestions, among them the question as to whether the proportion of gases did not vary. M. Teisserenc de Bort had endeavoured to ascertain the facts by using vacuum tubes, which were opened and sealed automatically at great heights.

Mr. J. E. PETAVEL remarked that the high temperature gradients obtained at Glossop Moor over the first height interval were doubtless due to the altitude of this station, which is 1100 feet (345 metres) above the sea. The first gradient is therefore the difference of temperature per 328 feet (100 metres) over a height of 492 feet (155 metres) only as compared with an average interval of 1310 feet (400 metres) for other British stations. As is well known the gradient very near the ground level is always exceptionally great.

The PRESIDENT, in conclusion, said they would all unite in conveying their thanks to the authors of the reports, Mr. Dines, Mr. Petavel, Mr. Harwood, Prof. Thrift, and Miss White, through the gentlemen who had read the papers. Captain Ley's report would, he hoped, be heard on a future occasion. Time did not admit of further speaking, but he might add that the mean curves of the vertical temperature gradient in the air were reminiscent of the typical curves of the vertical temperature gradient in the ocean and in seas, the region of rapid change near the surface passing gradually into an isothermal (or as he had ventured to term it, a homothermic) layer. In terminating the meeting he announced that an interesting Model of a Climatological Station, prepared by Messrs. Negretti and Zambra, was being exhibited in the tea-room.

January 16, 1908.—The average height of these ascents is over 13,000 metres, and a region where the temperature change with height is trifling has been reached in 26 cases.

Hail Shooting in Italy.

In the United States *Monthly Weather Review* for August 1907, there is a Note by Professor Cleveland Abbe, in which he says that the references to this subject in previous volumes of that publication have abundantly shown the probability that there is no rational basis for the efforts made in Italy and France to break up thunderstorms and prevent injurious hail by some method of cannonading. Neither the noise, nor the smoke, nor the heat, nor the commotion produced by grand vortex rings can be expected to have any considerable influence on the enormous cumulus clouds from which hail and lightning proceed. This conviction is now confirmed by a report read before the Royal Academy of Sciences at Rome (Accademia dei Lincei), on December 2, 1906, by Senator P. Blaserna, who is also Professor of Physics in the Royal University at Rome, and President of the Accademia dei Lincei. In 1902 Professor Blaserna was appointed by the Italian Government president of a special commission to investigate the subject. A locality that had suffered extremely in previous years was chosen as the field of operations, viz. Castel-Franco in Venetia, and 222 cannon of the most approved special type manufactured by the Greinitz Company were established ; each of these sends up a vortex ring 13 feet in diameter, and one additional cannon sending up a vortex 45 feet in diameter was subsequently added. As these vortices failed to ascend higher than 200 or 300 yards they evidently had no effect on the clouds ; therefore a higher station, the Casa Aulagne di Monteux, was occupied, so that the vortex rings attained 1200 yards, but still no good results were perceived.

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Then the Secretary for War and the manufacturers of pyrotechnics were appealed to. Of the latter, Marazzi, at Rome, succeeded in constructing bombs weighing 18 lbs. that were carried up to 2500 feet, where they exploded. During 1906, 250 broadsides were fired by the 222 cannon at Aulagne, and 60 of the Marazzi bombs were sent up, but still no good effects were perceptible. These negative results of a five years' campaign justify the commission in recommending that the Italian Government no longer encourage such expensive and useless work.

Audibility of Clock Bells.

In connection with Mr. Marriott's notes on sound (and the clock bell of St. Paul's Cathedral being heard at a distance), in the *Quarterly Journal of the Royal Meteorological Society*, vol. xx. p. 243, the following extract from *Notes and Queries* (November 16, 1907) is of interest :—

The great clock bell of St. Paul's possesses the peculiarity of sounding different notes from different positions and distances (of different degrees of audibility). The architect who superintended its recasting must have forgotten to provide a section, consequently the bell is "straight-waisted," which accounts for its *uncertain* sound. All curves in the section of a bell should be sections of a cone, and of the same cone. Probably (says Mr. Walter Scargill) the architect may have forgotten to read his Vitruvius, who shows that an architect must not be "music-deaf."

Influence of Temperature on the Iron Railway Viaduct at Crumlin.

Begun in 1853, the great viaduct in Monmouthshire was opened in 1857, but after its completion temporary difficulties were experienced owing to the expansion and contraction of so vast a body of ironwork, and the girders had to be supported on rocking links.

The records which were taken show a variation, owing to the difference of temperature, of $\frac{7}{16}$ of an inch in the length of the viaduct between 4.0 a.m. and 4.0 p.m. on June 12, 1861, a fine warm day following a cold damp night. The greatest difference in length aggregates over two and a half inches, the extremes occurring respectively on February 12, 1861, when the temperature was 32°, and on August 27, 1861, when the temperature was 90°, a difference of 58°.—*Great Western Railway Magazine*, October 1907.

The Furness Railway Wind-Gauge.

More than two years ago some allusion was made (*Quarterly Journal of the Royal Meteorological Society*, vol. xxxi. p. 189) to the wind-gauge erected in the neighbourhood of Ulverston to protect trains from risk in traversing a very exposed viaduct. A full description of this is now given in *The Railway Magazine* (October 1907, p. 337, *et seq.*) with an illustration. The apparatus is fixed at the west end of the Levens viaduct, and its actuating part consists of two boards, kept in a vertical position by springs, and the movements of which are shown on a chart by means of the customary pen and clockwork appliances. A pen is operated by either board according to the direction of the wind, and for greater exactitude of time, the chart paper, over sixty-five feet long, is perforated, the holes in the paper corresponding with studs in a clockwork wheel.

When the wind pressure reaches 32 lbs. to the square foot the spring boards referred to are adjusted to make an electrical contact, ringing bells in the signal cabins on either side of the viaduct, and when this occurs all trains are detained until the force of the wind moderates—any such interruption being telegraphed to the superintendent of the line. The apparatus is tested weekly. It has been at work since September 1903, and in February 1907 a velocity calculated as equivalent to 65 miles an hour was recorded.

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THE POSSIBILITY OF A TOPOGRAPHY OF THE AIR BASED ON BALLOON OBSERVATIONS WITH SPECIAL THEODOLITES.

By Capt. C. H. LEY, F.R.Met.Soc.

[Read December 18, 1907.]

Part I

That meteorology has hitherto been held by many to be a nebulous science, in which only vague generalisations or general averages can be dealt with, is no reason for assuming that it must always remain so, and it is with the object of drawing attention to one of the branches of meteorological investigation, which promises a considerable extension in the future, that this paper has been written.

I refer generally to the investigation of variations in velocity and direction of wind in the great middle strata of the atmosphere, by means of balloons followed by special theodolites, and, when possible, carrying instruments; and in particular to the results of the diameter method as carried out in Herefordshire this past summer.

Site.—Herefordshire is well situated for balloon ascents, because it is bounded on all sides by relatively large areas of land surface, especially in the direction towards which the prevailing winds blow, viz. towards points between N. and S.E.

The actual site was at Sellack, about 3 miles N.W. of Ross, on the neck of a long promontory running to N.E., and bounded by the river Wye, which here makes a sharp S-shaped bend through rather hilly country (see Figs. 5, 9).

Diameter Method.—The method is based on the direct estimation of range of the balloon from its apparent diameter, as measured by cross-threads in a telescope.

In the system found most convenient the threads form two or more horizontal triangles, crossed by equidistant vertical threads. The breadth of the triangles at the points of crossing is accurately determined, and the balloon is fitted in to a triangle, its diameter being estimated from the position it occupies in the triangle in reference to the nearest fixed threads (see Fig. 1).

The range being thus determined, an altitude and azimuth are read, and the position of the balloon fixed and plotted on a map.

In practice it is difficult, except when the range is great and the apparent motion slow (*e.g.* until diameters are less than say 25 seconds), to keep a balloon for any length of time between the cross-threads. During this period continuous momentary estimations are made until the eye can accurately gauge the rate of decrease of diameter and becomes aware of its position of fit, when a reading is taken.

The judgment throughout is made rather by appreciation of the area and curvature of the figure of the balloon in relation to the tangential threads, than by any actual linear measurement (see Fig. 1).

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Readings.—The following system was found the best for readings:—
Observer reads diameter in seconds, and Horizontal Arc to ¼ degree.
Assistant reads time to seconds, and Vertical Arc to minutes.
Before sending up a balloon the cross-thread constants were when

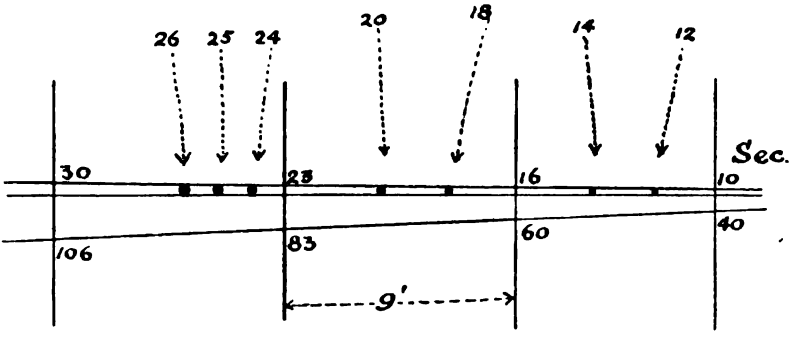


FIG. 1.—Cross-threads, showing Balloons.

NOTE.—Held 10 ins. from the eye, this diagram will appear of same size as the arrangement viewed with 45-power eye-piece.

possible checked on test points, the instrument accurately levelled and focussed, and the loss of gas in the balloon measured. In calculations all altitude angles were reduced to the centre.

Telescope.—The aperture was 1·9 inches, focal length 13½ inches.
Eye-pieces were used giving powers as follows:—

July	power 28
September	„ 40, 56
October	about 45

The 56 power was too high and bad definition resulted, but with 45 power the definition over the 26 minute distance occupied by the cross-threads was good.

Expansion Allowance.—The following expansion allowance, based on Boyle's law and an assumed decrease of temperature and pressure, was included in the theodolite calculations, and was considered accurate enough for practical purposes:—

0 – 5,000 ft.	. .	0·9	per cent per	1000 ft. of height.
5,000 – 10,000 „	. .	1·0	„ „	„
10,000 – 20,000 „	. .	1·1	„ „	„
20,000 – 30,000 „	. .	1·15	„ „	„

Solar Radiation.—To avoid solar radiation effect on gas as far as possible, as a rule the balloons were sent up shortly after sunrise or before sunset.

Rough experiments were made with thermometers placed inside coloured and colourless balloons in bright sunshine, filled with hydrogen and lung gases, which, though incomplete, tended to show that the solar effect in a colourless balloon at the earth's surface in the middle of a warm, still, dry day in the course of an hour is probably not great, but that the gas in a coloured balloon is much more powerfully affected. It seemed that the heating effect on the gas depends on the temperature

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of the rubber, and that the warming of the latter is a comparatively slow process. It was thought, therefore, that the effect from solar radiation on the hydrogen, especially in a colourless balloon, is not sufficient at the sunrise and sunset hour in the middle strata to appreciably affect the accuracy of a diameter estimation.

Loss of Gas.—A sudden loss of gas would have to be large to affect the apparent diameter. Thus a 5 per cent shrinkage of diameter means a loss of 15 per cent in volume, which, if it occurred in a few minutes, would rapidly cause an unusual decrease in the observed altitude angle, and affect the subsequent gradients of track.

This, however, is not the case where apparently rapid shrinkages, resulting in high observed velocities, occur.

In most cases the decrease in the altitude angle is normal, in many it is a relative rise, and in some cases an actual and large rise takes place (see Figs. 4, 6, 7, 8).

There is, however, a fairly constant loss of gas in nearly all balloons. Although insufficient to affect the diameter in the short space of time under observation, in the case of No. 35 it had to be taken account of.

Flag Tests.—The only test as to accuracy of observations on balloons yet possible of application has been as follows:—

A light silk flag folded over a meridian of the balloon is kept in place by a silk tape running through itself and drawn tight over the flag and meridian. The circumference over the tape is accurately measured, and the free end cut off to any desired length according to the height. The diameters, and therefore volumes and pressures, at the start and at the moment when the flag drops are thus known, and the height can be calculated and compared with the height at that moment as calculated from the observed theodolite observations of the balloon, with the correction for expansion. This, of course, assumes a certain normal decrease of pressure and temperature.

This speculation resulted as follows:—

1907.	Balloon.	Theodolite height.	Flag do.	Difference per cent.
Sept. 12	31	13,706 ft.	13,383 ft.	2·4
Oct. 3	35	8,285	6,236	25
,, 4	36	7,247	6,924	4
,, 7	37	13,580	13,603	·17
,, 15	40	13,432	13,045	3

As will be seen below, No. 35 on October 3 was sent up in quite unusual conditions. Its measured loss of gas before starting was very large (6 ins. circumference in 55 minutes). This was allowed for in all theodolite calculations in this case. The large difference is not to be attributed to observational errors, as the balloon was very clear and steady at a large angle of elevation and the diameter large.

The analysis of the track (see Fig. 10) also shows reason for believing that sudden loss of gas is not a probable cause of the difference, especially as this balloon attained an altitude of nearly 60,000 ft.

There remain the possibilities of the tape having worked loose, or of a large variation from normal conditions.

I have no reason for believing the former. If, in the unusual general conditions referred to later, the latter was the case, the pressure at 8000 ft.

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must have been that which would normally occur at 6000 ft., *i.e.* about 1·7 in. of mercury greater than the normal at this altitude.

With No. 40 on October 15 an improvement had been made by replacing the tape with a slack silk thread running through loops on the balloon and attached to a spring clip holding the flag. When the slack was taken in, and the thread pulled by the expanding balloon, the spring was released and the flag fell (see Figs. 2, 3). This arrangement would also be useful for dropping an instrument at a given height.

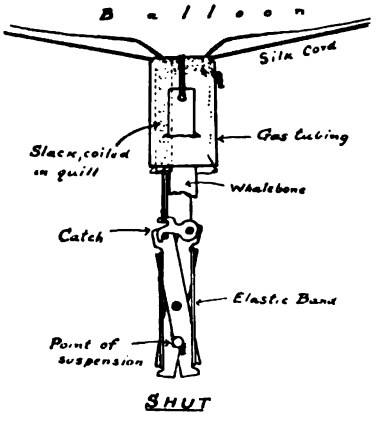


FIG. 2.

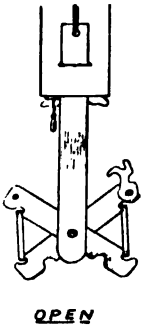


FIG. 3.

Formulæ used.—The formulæ used for theodolite calculations were as follows :—

$$\text{(i.)}\quad h = a\,\frac{(206085\ d \sin \mathrm{A})}{\mathrm{B}}.$$

$$\text{(ii.)}\quad h.d. = h \cot \mathrm{A}.$$

where
h = vertical height in feet.
$h.d.$ = horizontal distance in feet.
d = diameter in feet of balloon at start.
A = angle of altitude (to minutes).
B = observed diameter in seconds.
a = expansion percentage.

In the case of a flag-height calculation the formula used was :—

$$\frac{p}{\mathrm{P}} = \frac{\mathrm{V}}{v} \times \frac{273+t}{273+\mathrm{T}} \qquad \text{(Boyle's law)}$$

where p and P are the new and old pressures,
t and T „ „ temperatures
(t assumed from the theodolite height).

$\frac{\mathrm{V}}{v}$ was replaced by the fraction

$$\frac{\text{old circumference}^3}{(\text{old circ.} + \text{draw of tape})^3};$$

p was therefore ascertained, and the corresponding height obtained from the tables.

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Formula connecting vertical velocity and lifting force:

$$L = \mu\rho r^2 v^2$$

where L = lifting force, ρ = relative density, r = radius of balloon, v = vertical velocity, μ = constant. If no loss of gas occurred, and relative densities remained the same, L is a constant. Also ρ varies as $\frac{1}{r^3}$,

Hence $v \propto \sqrt{r}$

Part II

Results.

Balloons were sent up as follows:—

July	21 Pilots . . .	3 returned.
	3 Ballons Sondes .	1 returned.
Sept. and Oct. . . .	21 Pilots . . .	13 returned.
	3 Ballons Sondes .	3 returned.

Of the unreturned Pilots in September and October, several were seen to burst at comparatively low altitudes, and this was particularly the case with those that had been in store for some time.

The sizes used were as follows:—

1000 mm. C.T. Cos	1 Ballon Sonde
700 ,, ,, ...	4 Ballons Sondes
600 ,, ,, ...	1 Ballon Sonde
1000 ,, Paturel	2 Pilot Balloons
750 ,, ,, ...	9 ,, ,,
2 ft. coloured	18 ,, ,,
smaller English	16 ,, ,,

Several of the returned Pilot cards showed rapid probable velocities, notably Nos. 19A and 26. No. 26 was picked up at Stratford-on-Avon, 39 minutes after being lost to view.

Paturel's balloons were very efficient, and seldom lost gas to any extent.

July.—The July results were partly unsatisfactory, because a number of small, inefficient English balloons were used, the power of the telescope was only 28, the slow motion not perfect, and the cross-wires home-made of indiarubber solution. Wires of about 2 seconds apparent diameter could be obtained with the latter material, but only lasted a short time, and were subject to changes.

Thick wires, difficult to obtain otherwise, can, however, be made of indiarubber, and last well.

Except in 3 more accurate cases the July results have not been plotted. The results were sufficient, however, to confirm a suspicion entertained, *e.g.*, that local variations of velocity in the lower and middle strata are principally caused by undulations in the earth's surface.

The plans and sections, of which a few have been here reproduced, show the difficulty of accounting for these extraordinary variations by any mere theory of errors. Such a theory would have to assume a whole series of coincidences of great improbability.

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Summary.—To summarise the results:

Tracks of 21 balloons have been plotted, and sectional drawings of the 18 longest courses made.

There appear 22 cases of balloons travelling at first over low ground, then over a definite ridge or hill, and in each of these cases the vertical velocity shows a considerable increase over the hill. In 9 of them the increase is over 100 per cent, and in the majority of the remainder over 50 per cent.

Two cases appear where there is a ridge but no rise in velocity, while there are 14 cases of a rise without any definite hill or ridge.

Of these 14 cases, 1 is certainly due largely to the effect of cloud, and was in North-west wind conditions; 4 occur with different balloons over the same locality in the neighbourhood of the Malvern Hills; 3 with different balloons over another locality presenting special features; 3 in North-west wind conditions; and the remainder at the beginning of runs in the lowest and most variable stratum of air, and when, owing to rapid apparent motion, errors are probably greater.

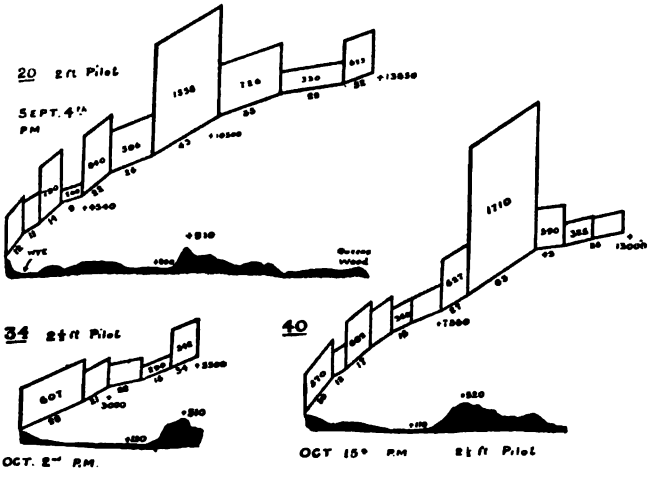


FIG. 4.

As a rule, over a hill both the vertical velocity and horizontal velocity increase, but the vertical velocity in greater proportion than the horizontal. On the other hand, over the lower ground before and after a hill it appears that the horizontal velocity usually increases faster, or shows a less decrease, than the vertical velocity, especially at the greater heights.

The ratio of the two components of velocity is of course shown by the slope of the track, which will be referred to below.

Horizontal Deflection.—The horizontal deflection of the wind due to the ground is much more marked when there is less wind, *i.e.* in anticyclonic conditions, in cyclonic calms, and at low altitudes. In such conditions the general tendency seems to be for the breezes to blow as far as possible along the contours of the ground. In the case of a valley the line of

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least resistance is found along the bottom of the valley; in the case of a ridge this line is again along the contours; but there sometimes appears a breeze along and below the farther edge of the ridge, in a direction indicative of the general direction of the superimposed current (see Figs. 5 and 9).

Horizontal deflection is often accompanied by a collapse of vertical velocity (see Nos. 13, 35, 16, 20), and in the case of 16 this occurs with a very strong wind.

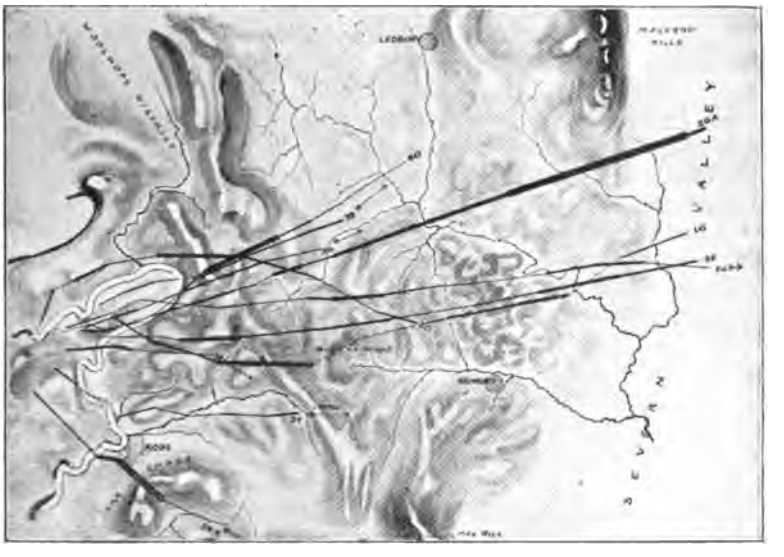


FIG. 5.

EXAMINATION OF EXCEPTIONS

Westerly Winds.—Exceptional Localities.—(i.) Between the Malverns and the lower slopes of May Hill lies a section of rough hilly country of no great height and cut through by several streams running down to the Severn.

The 4 balloons 16, 22, 24, and 26A passed over this section, and all showed remarkable and similar rises in velocity just before reaching the margin of the Severn valley (see Figs. 7 and 8).

With 26A, passing close to the Malverns at a height of about 18,000 feet, this increase was enormously magnified and evidenced by an actual rise in the angle of altitude (Fig. 8).

With 16, at a height of 8000 feet, the rise is followed by a drop over the further edge with a change in direction towards the Malverns, as had also been the case with the previous ridge.

With no definite hill immediately below to account for this, it seems likely that it is due to a lateral extension of the lift of air over the Malverns themselves, *i.e.* so to speak, to the flanks of a large "air-mountain" due to these steep hills. Supposing that May Hill and the

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Forest of Dean formed another "air-mountain," the section of ground referred to would lie under a high "air-neck" joining the two supposed mountains.

The terms "air-mountain," "air-neck," etc., are only used, however, to illustrate the raising or depressing effect on a particle. The actual isobaric surfaces are, it is suggested later, possibly raised over the valley preceding a hill, and depressed over the high ground in a manner corresponding to an anticyclone and cyclone respectively.

(ii.) In the cases of Nos. 22, 24, 26A, again, there is a sudden increase of velocities over Queen's Wood and the Kempley ridge just north of this wood. This ground is higher than that just noticed, but less rough, and is the source of many small tributaries of the Severn. Its height does not quite account for the jump of balloon velocities over it in an air-stratum between 5000 and 8000 feet high.

It is noticeable, however, that this damp ground marks the western limit of the Old Red Sandstone on the border of a comparatively impervious wedge of shale and limestone forming the actual watershed and separating this district from the Old Red Sandstone in the Wye valley.

In the case of 40, to the north of this area, there is no rise in velocities, which are quite low, and in the case of 16, just south of this area, there is an actual drop in velocities with a change of wind to the North, as previously noticed.

It would seem that this locality forms a coll or "air-ridge" extending from the general air-ridge to the west and overlooking a broad "air-basin" to the north lying over the ground basin between the Marcle and Ledbury hills.

Exceptional Wind Conditions.—The 3 cases of exceptional rises in velocity over low ground with a North to West wind are 36, 19A, and 19.

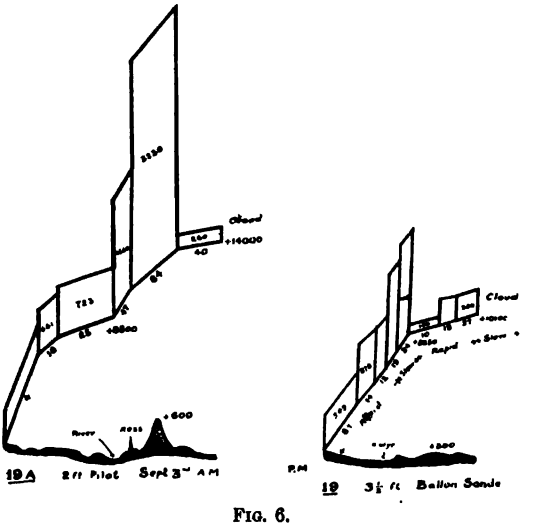


FIG. 6.

In these cases the exceptions occur in the lower and lower middle air strata, *i.e.* below 8000 feet.

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19 and 19A (Fig. 6) were sent up on the same day, September 3. A deep depression was moving away to the north over Norway, and dispersing.

In the morning 19A showed unusually little breeze and low vertical velocity up to 6000 feet, followed by a strong middle current from North-west with rapid ascensional movement over Wye valley until the Ross Hills were reached, when the combined effect of the town and the steep hill caused the balloon to swerve and shoot up with enormous vertical velocity, this velocity immediately dropping over the sheltered valley beyond, when the balloon entered the stratus bank lying over the Forest of Dean area. It was picked up at Newbury in Berkshire the next day, 68 miles south-east of Ross.

In the evening another depression was appearing over Ireland, and the wind was backing to West. Again there was a comparatively mild breeze in the lowest stratum, but rapidly increasing at about 3000 feet, until just beyond the Wye valley, at the first ridge, when another extraordinary jump occurred, principally in vertical velocity, at a height of about 7000 ft., followed by a swerve and sudden drop to low but increasing velocity towards the watershed, where it entered the stratus belt at 10,000 ft. The balloon carried an instrument which was picked up at Lewes, in Sussex, about 135 miles to the south-east of Ross, after a maximum vertical run of 45,000 feet.

The two tracks are of similar nature in somewhat similar conditions, show a general North-west upper current, a change of wind in the lower stratum, and a general levelling process taking place during the day in the matter of horizontal velocity.

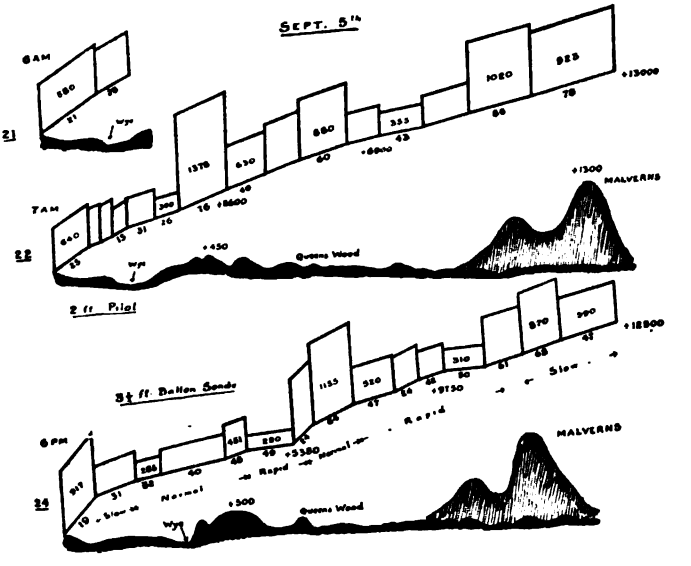


FIG. 7.

These diurnal effects should be compared with similar effects in the case of the three balloons 21, 22, 24, also sent up on the same day, viz.

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September 5, with a deep depression moving across the north of Scotland (Fig. 7). No. 36 occurred in anticyclonic conditions with a strong Northerly breeze in lower stratum, decreasing somewhat in horizontal velocity with altitude. The balloon was picked up at Tidenham (15 miles), having probably followed the Wye Valley.

Exceptional Cloud Conditions.—No. 10 balloon, sent up on July 20, was lucky in escaping thick banks of composite cloud at a short break in the afternoon. Its vertical velocities are unusally high, and horizontal velocities low over low ground in the stratum between 5000 and 10,000 ft. There was again little wind in the lower stratum, but a light North-west breeze in the higher. The balloon, however, after the first period follows the valleys with accuracy. It was picked up by Mr. Dines about 6 miles south-east of Oxford, after having attained a height of 67,000 ft. (Fig. 9).

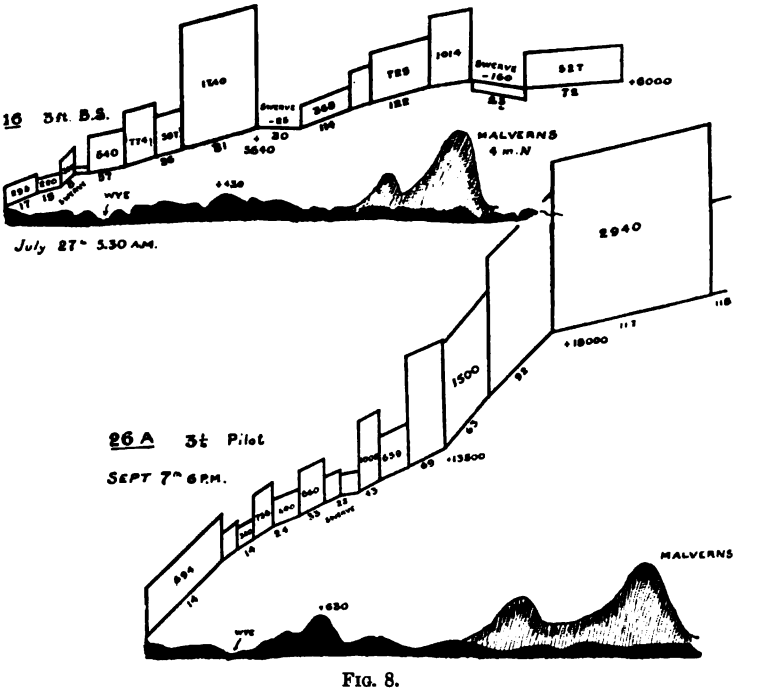


FIG. 8.

Easterly Winds.—(i.) The balloons 29-31A were sent up in anticyclonic conditions in September with very light airs at the earth's surface. The apparent effect of the bend in the Wye and the Harewood watershed is to form a region in the atmosphere extending to great altitude, which may, as regards the motion of a particle, be compared to a deep basin whose high rim lies over the watershed. As will be seen the balloons usually take to the bottom of this basin over the Wye at first, and under the influence of the local breeze and their lifting forces move in a spiral upwards approaching the rim, around which they speed with increasing velocities until attaining a sufficient velocity or meeting a sufficient upper current to carry them out of the area (Fig. 9).

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(ii.) No. 13 was sent up in semicyclonic conditions on July 24. There was a very sluggish South-east air moving up the Wye basin. The balloon makes several apparent attempts to escape from the "air-basin," by moving to either side of it with increasing velocities over spurs of the ground below. It appears to fall suddenly back over its course after two such attempts with a collapse in vertical velocity at bottom, finally running up the Hoarwithy stream towards the high "air-mountain" over the Aconbury Hill with increasing velocity until disappearing in stratus at 9000 ft. (Fig. 9).

(iii.) Nos. 35 and 38 were sent up in cyclonic weather. No. 38 follows the Wye Valley and Hoarwithy stream with high vertical velocity and decreasing horizontal velocity. The lowest velocity occurs over the lower part of the stream. Unfortunately the balloon burst when reaching the higher slopes of the basin over Little Dewchurch at a height of 9000 ft. A shallow depression was moving South-east over Cornwall

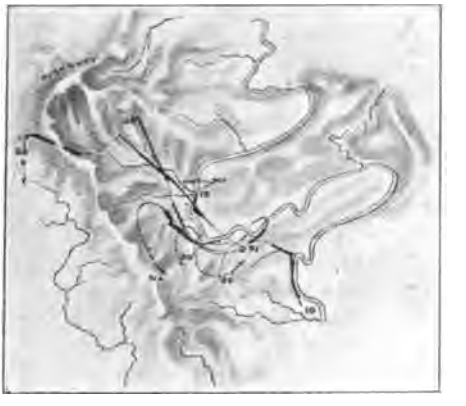


Fig. 9.

with heavy rain in its front portion. It returned over its track two days later, causing squally weather. The wind appears to be gradually decreasing in the upper layers, and probably changes similarly to 35 at the top of the ridge.

No. 35 is especially remarkable in view of the general cyclonic movement, and because its instrument record is instructive (see Figs. 9, 10).

The movement through the "air-basin" to the top of the rim is very slow and laborious, the balloon keeping to the valleys as long as possible, and changing direction when necessary with low vertical velocity (as in the case of 16). The rises and falls of ground are in general faithfully reflected by the vertical velocities, and the instrument record corresponds.

Directly the top is passed at an elevation of 19,000 ft., a slow Northerly air is met with blowing along the main ridge to the south. A depression at the time was over the Scilly Islands moving south. A light air at this elevation was therefore moving along the ridge towards the centre of the depression. The balloon, however, was picked

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up at Monmouth, 12 miles south of this place, and the instrument recorded a height of 59,000 ft. The remarkable fact therefore appears that there was practically no Easterly upper current on this occasion up to an enormous altitude, and that a very sluggish movement of the whole upper atmosphere was taking place to the South in the wake of the depression.

The Aconbury watershed clearly marks the general change of wind at an altitude of 19,000 ft., and we may consider this altitude to be near the top of a great "air-mountain" formed in these conditions by this 900 ft. hill.

Measurement of Effects.—An attempt was made to discover some relationship between the increment of vertical velocity over a hill and other factors such as the horizontal velocity of the wind and the height of the balloon above the hill.

Such a relationship, if it exists, is evidently a most complex one; moreover, a difficulty is met with at the start in the absence of a constant velocity to which variations could be referred. In the formula on page 31, the hydrogen velocity depends on the value of the assumed constant μ, which can only be determined approximately from the average of a large number of observations.

It seemed best in any individual case to refer variations to the average velocity over the run, provided the latter was sufficiently long. This, however, limits the investigation, and introduces the larger errors accompanying long ranges.

The averages were therefore worked out in all cases and substituted in the above formula, where the approximate lifting force L was known. The result showed large variations in the value of μ, but this perhaps was in part due to inaccuracy caused by determining L from the volume.

The variations in L were also examined as following from observed variations of velocity from the mean, but the cases in which an original value for L was accurately known were too few to give any definite results.

Moreover, owing to the low conductivity of the rubber it appeared from experiment probable that the relative density ρ is by no means constant, fluctuations in temperature of the air being communicated to the hydrogen, but relatively slowly.

The velocity variations of six balloons passing on different days over the same locality, viz. the Valley of the Wye and How Caple ridge, were however compared, with the following approximate results:—

1907.	No.	Size.	Period of time.	Rise in ground.	Balloon heights.	Increases. Percentage to V. V.	Percentage to H. V.
			Min.	Ft.	Ft.		
Sept. 4 . .	20	2 ft.	2·1	300	7500-10,500	162	65
,, 6 . .	26	1 m.	3·4	400	6250- 8500	56	109
,, 7 . .	26A	,,	4·2	500	7000- 9000	106	120
Oct. 2 . .	34	¾ m.	1·4	400	4800- 5500	89	112
,, 13 . .	39	,,	1·8	400	7000- 8000	240	107
,, 15 . .	40	,,	3·3	400	7000-11,000	350	250

No. 40 is a balloon in which the average is spread out over a greater distance than in the other cases. But it is also one sent up in more definite and deeper cyclonic conditions.

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An average increase, then, in horizontal velocity of South-west wind over How Caple ridge at this bend may be roughly set down at about 100 per cent normal conditions.

The average increase in vertical velocity is evidently a very variable quantity depending on many conditions; and a much larger number of observations must be taken to discover any relation between these.

Comparison of Velocities with Temperature Gradients.—The general rule in the atmosphere appears to be that the steeper the temperature gradient the less velocity of the wind, and *vice versa*. It may, however, be doubtful if this general law applies to any particular or sudden local variation of wind velocity, *i.e.* when the atmosphere is not free. It is of interest, however, to compare the instrument records of temperature with the wind velocities found by the theodolite at various heights in such few cases as were available.

No. 10 balloon differed from others in its temperature gradients owing to cloudy conditions.

The balloons 19, 24, and 35 were, however, sent up on fairly clear evenings.

The velocities of No. 19 in West to North-west wind have already been noted as exceptional.

An examination of the temperature gradient shows that it runs parallel with the velocity variations (see Fig. 6).

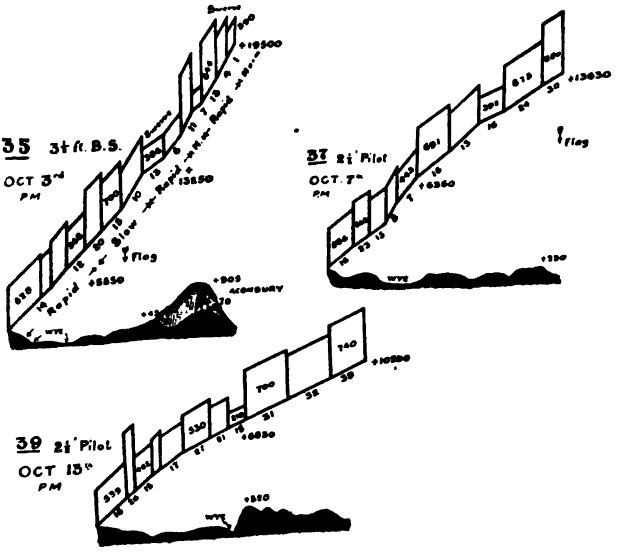


FIG. 10.

The initial decrease of temperature (1500-5000 ft.) is very rapid, with low horizontal velocity and roughly normal—but increasing—vertical velocity. From 5000 to 8000 ft. there is a sudden check in decrease of temperature almost amounting to an inversion; the vertical velocity gives the extraordinary jump already noticed, and the horizontal velocity rises from 12 to 24 miles an hour. From 8000 ft. to about

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10,000 ft. the temperature falls rapidly, the vertical velocity almost collapses whilst the horizontal velocity sinks low at first, but increases rapidly at about the 10,000 ft. level.

The balloon now disappears in stratus cloud lying just over the watershed. The temperature gradient, however, is suddenly checked. This check may be due to the cloud, but coincides with the ridge over which high velocities would be expected, moreover the temperature again falls rapidly at a later period corresponding with lower ground and lower velocities beyond.

An examination of Nos. 24 and 35 shows a similar correspondence of temperature and velocity gradients (see Figs. 7, 10).

The case of 35, however, is unusual because the horizontal velocity is throughout the track low. The gradient of track is steep, the vertical velocity nowhere extreme, but varying according to the ground. The temperature gradient thus follows the variations of vertical velocity and the ground.

These isolated cases are, no doubt, insufficient to deduce any conclusion, but they do point to a correspondence of temperature gradient and local velocities. That the temperature should decrease at a less rate the faster the balloon rises seems difficult to account for, unless greater radiation effects or an actual convection current is taking place over the locality where this occurs.

Gradients of Track.—The ratio of vertical velocity to horizontal velocity obviously depends on the slope of the track, *i.e.* $\tan B = \frac{V.V.}{H.V.}$ where B is the angle of slope.

Now, it appears that a maximum value for B usually occurs at some distance from a hill on its windward side, and this is noticeable in the exceptions as well as in the rule. The maximum is followed by a minimum over or just before the high up slopes of the hill, whilst over the top and just beyond, the slope again increases. The vertical velocity and horizontal velocity vary respectively in direct and inverse proportion, the maximum value for both velocities occurring at the outflow over the hill. The balloon, in fact, takes a jump up at some preceding point, often a lower ridge, rising sufficiently apparently to cross the valley area. This preliminary rise at lower elevation is sometimes carried out with a slow spiral motion.

It then performs a slow swoop with downward tendency over the valley till near the steep slope of the hill, when it rushes up and out over the top with upward tendency at first and greatly increased velocities.

Variations of Pressure.—The law suggested for the free atmosphere by Clayton and Egnell ($Vd = \text{constant}$) does not strictly apply to sudden local variations.

In these cases, as is well known in the case of cyclones and anticyclones, the velocity of the wind depends largely on the barometric gradient, *i.e.* on the relative rate of increase or decrease of the pressure.

If, therefore, it is true that a hill increases the velocity of wind blowing over it and a valley decreases this velocity, it seems possible that a valley increases the pressure and a hill decreases it throughout the strata in which the effect was observed. The isobaric surfaces would be raised

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over the valley and depressed over the hill, in section appearing as inverted basins and hills respectively, whilst in plan following the features of the ground. The terms "air-basin," "air-mountain," etc., could only therefore be used with this significance. It also appears that the actual fluctuation in the pressure might be minute, yet as it occurred in a short relative space the barometric gradient would be suddenly and sharply affected, causing sudden accelerations to total velocity and to both vertical and horizontal components.

Horizontal deflection of a current moving rapidly across these localities, under independent general forces, might not be great except under favourable conditions. The tendency of motion laterally along the isobars might be replaced by a motion vertically, as appears the case near the centre of a cyclone.

Water Analogy.—The atmosphere does not present a case strictly analogous to a stream of water, because it is a compressible mixture of gases thinning off into space with no known upper surface.

As Mr. Froude points out, in a stream of water passing over a rocky bottom, swirls or eddies are produced at the bottom with vortex motion extending upwards for a certain height in the liquid.

At the surface, if the depth is not too great, an undulation takes place, the level being raised just before the point of a rock, depressed just over it, and raised just beyond.

The differences of pressure are, in fact, transmitted through the body of the liquid to its upper surface, there causing an undulation under the influence of gravity.

May we not suppose, then, that a similar process takes place in a moving body of air passing over valleys and hills, and that a mechanical action due in part to obstruction at the bottom causes variations of pressure which are transmitted through the body of the atmosphere to its distant confines?

And further that, without much horizontal deflection (except near the earth's surface), particles of air moving at great elevation in a general current over these disturbances, affected also by differing radiation effects or actual convection currents over the hills, would be accelerated and retarded with large upward or downward components of motion.

Is it not also possible that an area is often formed, say by a superimposed current, presenting something analagous to a surface in the case of water, where condensation takes place in a cloud form presenting in visible shape the reflections of hill and valley disturbances many thousands of feet below?

If these observations are in the main correct, the suspicion is justified that the vertical velocity of a balloon travelling upwards through the lower and middle atmosphere is by no means a uniform one, and it appears that there are sudden fluctuations in both vertical and horizontal velocities of wind which, though variable in different conditions, are mainly of a permanent nature, due to the shape of the earth's surface.

The measurement of these effects can be carried out by balloons and special theodolites, and a topography of the air made in any locality, which, studied in conjunction with the records of the instruments carried

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and with relation to general atmospheric conditions, presents a field of research of fascinating interest and of great possibilities.

NOTE.

Explanation of Diagrams.—The following scales apply to the printed diagrams :—

Horizontal scale for Plans	4 miles	=1 inch.
,, ,, ,, Sections	5 ,,	=1 ,,
Scale for Ground Heights . . .	about 0·4 ,,	=1 ,,
,, ,, Balloon ,, ...	2 ,,	=1 ,,
,, ,, Vertical Velocities	about ½ m. per min.	=1 ,,

The vertical velocities are written in the parallelograms over the balloon tracks, and are in feet per minute. The horizontal velocities are written underneath the balloon tracks, and are in miles per hour. The temperature gradients, where an instrument was carried, appear under the horizontal velocities.

ADDENDUM.

A further test as to the accuracy of the method for range-finding has more recently been applied. On January 11, 1908, a mark consisting of an upright board tapered at the ends, 3¼ feet high and 10 inches broad, was erected on the top of one of the Welsh hills to the south-east of Bangor. On the 12th, Professor Orton and I each took 5 momentary readings of the angle subtended by this board at an observing point at Bangor, without recalibration of the cross-threads. The cross-threads were then cleaned and recalibrated, the new values of the constants differing by 4 seconds from the original ones. On the 13th I repeated the observations.

The horizontal ranges were then calculated from the mean of each series and from the observed altitude, and compared with the actual range as measured accurately on a 1-inch Ordnance Map.

The following tabular statement shows the results :—

January 12.	*Orton.*	*Ley.*	*January* 13.	*Ley.*
	22 secs.	20½ secs.		20½ secs.
	21½ ,,	21 ,,		21½ ,,
	21½ ,,	21 ,,		21 ,,
	21½ ,,	20½ ,,		21 ,,
	22 ,,	20½ ,,		21 ,,
Average .	21·8 ,,	20·7 ,,		21 ,,
(Elevation +3° 59′)				
Calculated Range	5·80 miles	6·11 miles		6·03 miles
Map ,,	6·18 ,,			
Error per cent ·	6·1	1·1		2·4

The observation of a narrow rectangular object is more difficult than that of a circular area; moreover, the difficulties caused by shimmer due to varying refraction at such a low angle of elevation are greater than those occurring at normal balloon altitudes.

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DISCUSSION.

Mr. C. J. P. CAVE remarked that he was somewhat disconcerted at the results of Captain Ley's observations. He himself had made a large number of observations of pilot balloons by the one theodolite method, assuming the rate of ascent to remain constant; Captain Ley's observations seemed to show that the rate of ascent was far from uniform. But if there is an upward current over a hill there must be a downward current beyond it, and the one theodolite method probably gives a fair idea of the direction and velocity of the wind if average values are taken, though any single observation might be unreliable. One may frequently see the effect of an upward current over a hill in the cloud capping it; he had seen a good example in the Isle of Wight, where the clond formed an outline of the hill, and extended to about three times the height of the hill. From some of the records of the International Commission of Scientific Aeronautics, it would seem that when a balloon gets into a warmer stratum its ascensional velocity diminishes, which is contrary to Captain Ley's observations.

Mr. W. W. BRYANT said that he had been much interested in Captain Ley's paper, but to one in the habit of using a micrometer for measuring small objects it is not easy to admit the advantages of the suggested arrangement in place of a micrometer. Fitting in the balloon in the intermediate sections seems open to considerable uncertainty, though at the intersections it would be easier. With practice, however, he thought one could get fairly good results, and, as Captain Ley said, this is the best form of several he has tried. He (Mr. Bryant) was prepared to admit that he ought to know best about this particular form of observation. One or two other points he would mention. As the density of the air decreases with the height, one would expect the effect of a range of hills on the successive "level" surfaces upwards in the air to be considerably exaggerated, so that an effect at a height many times greater than that of the hill seems quite reasonable. The fact that it is not exactly an ascending current, but a bend in the stratum, so to speak, would lead one in such a case to accept as quite natural the slow decrease in temperature with greater ascensional velocity which Captain Ley seems to find. On this, however, he (Mr. Bryant) could not claim to speak with any authority, so perhaps somebody would correct him. As he was allowed to see the large map on which the tracks were laid down, and as he was born in sight of the Malvern Hills, May Hill being also a familiar landmark of the neighbourhood, he was particularly interested to notice that one of the largest tracks (No. 22) ended just over his native village.

Capt. A. CARPENTER, R.N., wished to confirm the remarks as to the effect of an uneven bottom to a stream causing disturbances at the surface. It was well known to navigators that where there was a strong current in a confined channel overfalls occurred at the surface above obstacles that might be as much as 15 or more fathoms deep.

Dr. W. N. SHAW remarked that, so far as he knew, there was no precedent with which to compare Captain Ley's results. This circumstance, while adding to the interest of the paper, also added to the difficulty of grasping the precise meaning of the results. He thought there had been a little temptation to jump to the conclusion that the increase of the velocity over a hill must be due to vertical velocity in the atmosphere caused by the hill. In flowing water there certainly was a variation in the surface motion when a deep current ran over an obstacle, but the vertical velocity of the balloon was due, in the first place, to the difference of density of the balloon and surrounding air, and it was too soon to say definitely that the acceleration of the balloon in the atmosphere represented the effect of the hill upon the motion of the air, and to put all the observed difference upon the vertical velocity of the air without inquiring into

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changes of density. The conclusion would be more nearly justified if the temperature gradient was found to increase when the vertical velocity increased, and not to diminish. When no cloud is formed, air with an upward motion is cooling at 1° C. per 100 metres. This is the maximum rate of decrease in temperature, and the balloon carried upward by a rising current without cloud ought to show it. A balloon in the upper regions might be expected to show less temperature gradient if the air was not rising. To a certain extent the absence of this contrast is evidence to the contrary of the suggestion that the effects noticed are due to the vertical movement given to the atmosphere by the obstacles of the surface. He would be glad if Captain Ley would continue these observations, testing them by repetition under different circumstances.

Another point to be noted was, that the method itself must be a great strain upon the observing capacity. A telescope is incapable of producing a point as an image of a point, if the distance of the object exceeds that corresponding to the resolving power of the telescope. The condition that the telescope should produce an image is, that the angle which the object subtends at the centre of the object glass is not less than that which the wave length of light subtends at the distance of the aperture of the object glass. Beyond that distance diffraction begins to interfere with the formation of a true image. With a metre balloon at a distance of 10 kilometres you have got an angle of $\frac{1}{10000}$ part of a radian about the same angle as the wave length of sodium light subtends at a distance of 2 inches. This is close up to the limit of observation with the telescope of a theodolite, and it was therefore desirable to verify the accuracy of the method. One easy way of testing was to observe the apparent size of a sixpence at 200 metres. This subtends the same angle as a metre balloon at 10 kilometres. They could thus find to what degree of accuracy they could measure a distance by Captain Ley's method. The measurements could also be tested by observations with two theodolites. He felt justified in asking Captain Ley for some such elaboration in order to give them the degree of accuracy of the measurements somewhat more in detail.

Mr. W. MARRIOTT said he had been much interested in Captain Ley's paper. His observations seemed to throw considerable light on the formation of clouds. A cloud would sometimes be formed without any apparent cause, but would probably be the result of an upward current induced by the configuration of the ground. Possibly the President could tell them what the rainfall was in the neighbourhood of hills. After referring to the heavy rainfall at Seathwaite, Mr. Marriott showed some lantern slides to illustrate the influence of hills on clouds. He also referred to some special forms of clouds, as the helm bar in the neighbourhood to Crossfell, Cumberland, and the cloud sometimes formed over the Lion's rump at Cape Town. When staying at Malvern one day last summer, he had watched the clouds coming over the Malvern Hills; they seemed to come round, then almost to disappear, and subsequently to re-form. Probably this was due to the phenomenon explained by Captain Ley.

Mr. E. S. BRUCE remarked that he considered it important to both the sciences of meteorology and aeronautics, to map out in this way all the various currents and disturbances of the air. These observations would be of the most extreme importance, preliminary to aeroplane voyages, as pointing out the dangerous places. In the case of uprushes of air over hilly districts a balloon would not be seriously affected where an aeroplane would probably be upset.

The PRESIDENT (Dr. H. R. MILL) said that the action of air passing over a hill in producing an increase in the amount of rainfall hardly led him to the same conclusion as that arrived at by Mr. Marriott. If these tremendous uplifts really occurred, the cause would be much too great for the comparatively moderate effect, as far as rainfall was concerned. He would like to see experiments tried in some place where there was a very much greater elevation

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of the earth's crust than near Hereford. The valley of the Eden would be most suitable, as the escarpment of the Crossfell range was the most continuous and highest mountain wall in England, and rising as it did east of the plain, the position was eminently adapted for such observations, as a balloon sent up on the western margin of the Eden valley would almost certainly drift over the Crossfell range. Meanwhile suspending judgment on the matter, he would invite Captain Ley to reply to the remarks which had been made.

Capt. C. H. LEY, in reply, said that Mr. Bryant had suggested using other forms of micrometer. He had, however, after experience come to the conclusion that one would require three hands to use any usual form of micrometer whilst keeping the balloon in the required position in the field of the telescope.

With regard to Dr. Shaw's remarks he had not meant to assert that a check in temperature gradient was necessarily due to an ascending current of warm air, but rather to suggest this explanation as a possible one in certain cases. He thought that it was too early to come to a conclusion on this point. Regarding the optical question it might be perfectly true that a 2-inch object glass could not resolve two points of light less than $2\frac{1}{4}$ seconds apart. To distinguish between a circular area of 20 seconds in diameter and one of $22\frac{1}{4}$ seconds diameter with such an aperture was, however, he suggested, an entirely different proposition. From experience he felt certain that the difference between a 20-second area and a 21-second area could be fairly easily made out. To take a parallel illustration, it was much harder for the eye to distinguish clearly the edge of the narrow part of a church steeple near its high point, than to appreciate the edge lower down where there was a broader mass of the building.

With reference to Dr. Shaw's desire for further details of the tests applied, the figures for the Flag Tests are, with the detailed tables, now in the Society's office. Tests as to ranges of distant fixed objects of known size were made in September, but this was before any idea of plotting the tracks was entertained, and no record was kept. Moreover, the objects were of a comparatively large size, subtending angles of one minute or more, and great comparative accuracy was therefore obtained. The constant values for the cross-threads were obtained by measurements of known black circles at a known distance, so frequently carried out with the same instrument by him and others that the personal errors were thoroughly known, and the doubt, that there would not be relative accuracy in one set of observations by the same person on fixed objects in clear conditions, was never entertained.

"Dust Devil."

In the Report of the Surveyor-General of Ceylon for 1905 there is an account of an unusually good specimen of what is popularly known in the East as a "dust devil," which was observed by Mr. J. B. M. Ridout of the Survey Department, Colombo. His description is as follows:—"It was about 12.30 p.m., and I was at the corner of this block opposite the Fort station when I first saw it. It was then to the north side of Norris Road, just on the Fort side of the Racquet Court, the appearance it presented being a rough vertical column of dust about 30 ft. high, perhaps 4 ft. in diameter at the top and where it touched the ground, and 8 ft. at a height of 3 ft. from the ground. It was revolving rapidly in the reverse direction to the hands of a clock when looked at from above. It lasted about three minutes, and moved along the road in the direction of the Fort, finishing in the corner at the north-east end of the Fort station, where the posts carrying the telephone wires are. It was then about 40 ft. high, being, except just at the bottom, in the form of a column about 2 ft. in

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diameter with perfectly smooth sides, and at the top the dust was rising just like the smoke from a chimney. It was still perfectly vertical except the top 10 ft. or so, which were inclined to the south. At the bottom it bulged out, being about 3 ft. in diameter where it touched the ground, and 4 or 5 ft. at 3 ft. higher; in fact, the whole column was in shape very much like the glass of an enormous thermometer. At the end of the Fort station it disappeared. Whether the currents of air were broken by the roof of the station, the tree and the telephone posts, or whether it faded away because there was no dust on the railway line for it to pick up, I do not know; but I am inclined to think that the former is more probable, as I went at once on to the railway platform, but was unable to detect any disturbance either on the permanent way or on the surface of the lake. I should have gone to see what sort of a track had been left on the road, but could not as my train was due.

"The wind at the time was practically *nil*, what little there was being North-east."

Penalty for Counterfeiting Forecasts.

The Agricultural Appropriation Bill for the fiscal year ending June 30, 1906, (*Statutes at Large*, vol. xxxiii. part 1), contained the following legislative item:—

Any person who shall knowingly issue or publish any counterfeit weather forecast or warnings of weather conditions, falsely representing such forecasts or warnings to have been issued or published by the Weather Bureau, or other branch of the Government service, or shall molest or interfere with any weather or storm flag or weather map or bulletin displayed or issued by the United States Weather Bureau, shall be deemed guilty of a misdemeanor, and on conviction thereof, for each offence, be fined in a sum not exceeding five hundred dollars, or be imprisoned not to exceed ninety days, or be both fined and imprisoned, in the discretion of the court. (See Act of Congress approved March 3, 1905.)—*U.S. Monthly Weather Review*, June 1907.

Memorial of a Wet Summer.

The Rev. Frederick Ackerley gives, in a recent number of *Notes and Queries*, an account of an upright stone pillar which was erected (by a person of the name of Harrison) some twenty-five years ago to commemorate a very wet period. It stands in a field adjoining Brows Farm in Grindleton (in the West Riding of Yorkshire), and was put up as a memorial of a wet summer, when the rain fell every day for thirteen weeks in succession.

The Greatest Height reached by a Ballon-Sonde.

A balloon sent up by the Meteorological service of Belgium, on September 5, 1907, holds the record for greatest height. This balloon, starting from the Uccle Observatory at 6.58.30, reached a height of 85,270 ft., or 16 miles, at 7.53.31. The barometric pressure at this point was only 0·67 inch.

Previous to this the more memorable ascents were:—

1906, May 3, at Strassburg	. . .	79,400 feet
„ June 7, at Milan	. . .	78,085 „
„ November 8, at Paris	. . .	78,380 „

A balloon sent up by the Meteorological Service of Belgium on July 24, 1907, reached a height of 69,350 ft.

In the *Annuaire Météorologique* for 1907 there will be found an interesting article by M. J. Vincent on "The Ascents of Ballons-sondes in Belgium" (with figures and maps).

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INDICATIONS OF APPROACHING FROST.

By RICHARD STRACHAN, F.R.Met.Soc.

[Read December 18, 1907.]

The *Quarterly Journal of the Royal Meteorological Society* for April 1906 may be cited as showing the connection of meteorology with the affairs of everyday life. Mr. F. Druce has said that "the people of this country should wake up and get some means of foretelling destructive frost"; and two past Presidents of the Royal Meteorological Society have remarked, Mr. E. Mawley "that our fruit-crops are greatly at the mercy of late spring frosts," and Mr. R. Bentley "that it would be of immense value if accurate forecasts of frosts in the spring months could be established in this country."

There can be no doubt of the importance to horticulturists, and agriculturists generally, of being able to foresee the coming on of frost or hoarfrost. Every one recognises this when consideration is given to the havoc wrought by frost on unprotected crops and plants. Frosts in spring, even in June and occasionally in July, in England cause much loss or depreciation of fruits and plants. Mr. J. Glaisher, in Hughes's *Fourth Reading Book*, 1855, wrote: "In calm and clear nights a terrestrial radiation thermometer may read less than 32° in every night of the year"; and added: "The greater coldness of grass than that of air in clear and calm weather, in places sheltered from the sun but open to a considerable portion of the sky, may continue all day as well as all night." Mr. R. H. Scott, in his *Elementary Meteorology*, states: "A knowledge of the dewpoint in the evening enables them [gardeners and others] to form a fair estimate of the probable minimum temperature on the grass during the night. If the dewpoint be found to be above 32° they need not fear that hoarfrost will occur; but if it be below 32° it is advisable to cover up delicate plants for fear of their being nipped if the sky should clear before sunrise." This hardly goes far enough, for a thermometer on grass may fall many degrees below a dewpoint which is much above 32°; just what happens in the warm months occasionally.

That this teaching is not sufficient the following instances will render evident. They are from the *Greenwich Observations* for the year 1902. The daily means for the dewpoint occur in the early morning and evening, so that they may here be taken for evening observations; and the minimum temperature on grass during the night is taken the following morning, with the state of the sky in the interval, as follows:—

		Dewpoint.	Grass.
January	4	45°·7	29°·0, bc
	5	36·4	29·0, „
	12	43·2	27·2, „
	13	32·8	18·5, hoarfrost, cb
	17	40·3	20·4, slight fog
	23	44·5	29·5, bc
	24	37·9	25·2, hoarfrost, mist
	27	38·1	27·5, bc, r
	28	36·7	22·5, hoarfrost, b
July	11	44·5	30·8, heavy dew, b

These dewpoints being above 32° do not indicate proximate frost

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unless the sky becomes clear during the night; if the sky continues overcast there will be no frost the next morning; but the grass temperatures all show that there must have been frost during some portion of the night. On June 8, 1906, the mean temperature was 55°·4, next morning the grass was 29°, the sky having been very clear during the night.

Accumulating facts, co-ordinating them, and drawing inferences is the inductive method of science. What has been said is borne out by a study based on the observations of the entire year 1902:—

1902.	Mean Temperature. Air at 9 p.m.	Wet-bulb at 9 p.m.	On Grass.
	°	°	°
January	41·6	39·9	31·1
February	35·1	33·8	25·1
March	44·1	41·9	31·1
April	45·8	42·7	28·8
May	47·7	45·6	33·0
June	55·9	53·2	41·0
July	59·4	55·2	43·4
August	57·9	55·6	44·7
September	53·9	52·0	39·7
October	48·7	46·9	37·1
November	43·7	42·5	33·0
December	40·8	39·0	33·1

The dewpoint may be easily inferred from the depression of the wet-bulb; and it will be seen that the grass was colder than the dewpoint in every month. However, this exposition does not assist prevision of frost. Investigating the subject from a daily point of view may be more hopeful. This may be set forth as follows, under the same headings, with addition of weather notations for the interval of night:—

	Air at 9 p.m.	Wet-bulb at 9 p.m.	On Grass.
	°	°	°
April 30	50·1	45·1	29·0, op
May 1	40·6	39·2	27·0, cp
3	45·4	44·1	27·4. bc
4	...	...	25·4, dew, bc
5	39·9	38·3	23·0, hoarfrost, bc
6	40·1	38·4	25·2, cb
7	41·0	40·6	24·8, o
8	42·2	40·2	27·1, hoarfrost, b
9	42·0	40·2	24·8, ,, bc
10	40·1	39·3	24·9, bc
11	...	...	27·0, dew, o
12	43·0	40·3	24·0, hoarfrost, b
13	39·7	37·4	22·6, ,, bf
14	39·2	38·8	25·3, ,, bc
June 9	46·9	44·4	29·8, heavy dew, b
July 11	51·4	49·0	30·8, ,, ,, b
Sept. 18	42·7	42·0	29·4, hoarfrost, b
19	48·0	46·0	29·3, dew, b
24	48·3	47·2	30·5, heavy dew, b
25	48·3	48·0	30·1, ,, ,, b
26	49·3	48·9	31·9, dew, b
Oct. 1	51·3	49·0	30·7, op
7	48·4	47·6	30·4, bc
18	46·3	44·8	27·8, bc
22	49·8	46·5	31·2, dew, bc
28	51·1	50·0	29·6, ,, b
30	47·1	43·6	29·2, hoarfrost, b

In May the grass was colder than 32° on 15 days. The psychrometer at 9 p.m. on the preceding days gave no indication of such cold,

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but the evenings or nights were clear and may have led to anticipation of frost on the ground the next morning. June had frost in the morning of the 10th, accounted for by clear sky after midnight. July had frost in the morning of the 12th, accounted for by clear sky all night. August had no frost. September had frosts on 5 days, no wet-bulb or dewpoint indication of them, but the sky was cloudless for all these nights. October had frosts on 6 days, and the same remark applies, except for the night of the 1st, which was overcast. There is no need to discuss the other months in this manner, for frosts are frequent in them, and expected. January, for instance, had frosts on 18 days, February 15, March 19, April 21, November 11, December 15. In all these cases the grass was colder than the air at 4 ft., colder even than the dewpoint, frequently very much colder. Indeed, it will be found by comparing the mean monthly air temperatures with their corresponding wet-bulb temperatures, or their dewpoint values, with means of the grass temperatures, that the latter are almost always the least.

In the majority of cases the evening dewpoint is no indication of frost unless the sky during the night becomes clear, or a radiation fog is on the ground with a clear sky above it. The grass may be below 32° without dew being observed, perhaps because too slight, or it may have been obliterated by rain or dissipated by rise of temperature. Nevertheless not every night having a clear sky will be attended by a temperature on the grass sufficiently low to produce frost. Forecasts, therefore, may frequently fail, but it is better that they should sometimes do so than that we should suffer from an unexpected frost against the destructive effects of which precautions had not been taken. Better to be wrong with this problem than right; but if you are right and have taken due precautions you have your reward.

The problem cannot be adequately expounded by the averages published for meteorology. For the purpose of making forecasts the psychrometer should be noted at or after sunset, or at 9 p.m., and the amount of cloud at the time, and during the forepart of the night if convenient. The dewpoint can then be found by Glaisher's *Hygrometrical Tables*, or roughly by taking the difference between the two thermometers from the reading of the wet-bulb. When the dewpoint is at or below 32°, frost is in evidence, but may be evanescent, due to a rise of temperature, with change of wind, rain, or overcast sky. Even when it is above 32°, if the sky is clear it is probable that the temperature on the ground will go low enough for frost to form. Thus the evening observations should lead to a good guess of what may happen during the night; presumably if the sky is very clear, however hot the weather, there may be hoar frost or dew the next morning, so that precautions should be taken.

Addendum.

Mr. Strachan explained on the blackboard the general problem by the following empirical scheme:—

Air, 9 p.m.	Stars Visible.			
	All.	Many.	Few.	None.
°	°	°	°	°
60 . . .	30	40	50	60
50 . . .	25	33	42	50
40 . . .	20	27	33	40
30 . . .	15	20	25	30

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The air being 60°, and brilliant starshine, the indication is for something greater than 30° on the grass, and there is no fear of frost for temperature above 60°; if 50°, nothing less than 25° need be expected, but then there is a probability of frost with bright starshine; and the probability increases at 40°, for frost may occur even with partial starshine; while for 30°, frost is in evidence for all states of the sky. For no starshine the sky must be overcast, and, if the weather is rainy or damp, the grass may remain, as well as the air, at the same temperature during the interval, unless there is an atmospheric change of temperature, then the minimum at 4 ft. and that on the grass will be alike.

Scintillation and Rippling of Distant Lights.

I was at Brighton on Sunday, November 3, 1907. The weather was dull in the morning, and some rain fell between 1 and 2.30 p.m. The clouds cleared a little in the south-west about 3 p.m., and the sun then came out for some time. This was followed by a brilliant sunset, the clouds being tinged with beautiful colours. Soon after 5 p.m. I saw the electric lights at Worthing. As it grew darker these became brighter. I then noticed that the lights scintillated or twinkled very much like stars. There was also the appearance of rippling or waves along the row of electric lights. I do not remember to have noticed any similar appearance of the twinkling and rippling of the lights anywhere else.

Worthing is twelve miles west of Brighton, and, owing to a slight bend in the coast-line, it is seen over the sea. The wind was from the South, and was only light in force. It is probable that there were inequalities in the velocity of the wind over the twelve miles of sea, and so these may account for the scintillation of the lights and also for the rippling, which was apparently from south to north.—WILLIAM MARRIOTT.

International Meteorological Committee.

A meeting of the International Meteorological Committee was held at Paris on September 10, 1907, and following days. At the close of the session M. Mascart resigned the office of President, and Dr. W. N. Shaw, Director of the Meteorological Office, London, was elected President. Dr. G. Hellmann, Director of the Prussian Meteorological Institute, was elected Secretary in the place of Prof. Hildebrandsson, who retired upon his withdrawal from the post of Director of the Swedish Meteorological Office. M. Angot (Paris), Dr. H. E. Hamberg (Sweden), Dr. Maurer (Switzerland), and Mr. R. F. Stupart (Canada) were elected to fill the vacancies on the Committee.

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PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

November 20, 1907.

Ordinary Meeting.

HUGH ROBERT MILL, D.Sc., President, in the Chair.

WILLIAM SMITH ALLELY, 39 St. Oswald's Road, Birmingham ;
HARI GOPAL BANERJI, M.A., Khatmandu, Nepal, India ;
Capt. E. HAMILTON BATE, H.M.S. *Hannibal*, Devonport ;
R. JOHNSON CLARKE, F.S.A., Monrovia, Liberia, W.C.A. ;
ARTHUR DALLAS, 4 Peking Road, Delhi, India ;
CHARLES NEVILE DAY, Easton, Stamford, Northants ;
JOHN DESMOND, R.V.S., G.M.V.C., Adelaide, South Australia ;
Capt. JOHN ELMES, Anchorage, Clifton Avenue, West Hartlepool ;
Capt. HUGH FINDLAY, 36 Gracechurch Street, E.C. ;
WILLIAM GAW, 88 Avenida Espana, Santiago, Chile ;
HEMCHANDRA GORSAIN, Tezpur, Assam, India ;
Capt. GEORGE GREGORY, 18 Leadenhall Street, E.C. ;
Capt. HUGH HOLLIES, Castle Rising, Norfolk ;
HENRY J. HUNT, The Priory, Wimbledon Common ;
Capt. EDWARD GATES JAMES, Fradswell, Stafford ;
ARTHUR LANDER, 17 High Street, Canterbury ;
Capt. WINDEYER GEORGE LINGHAM, 67 Woodland Rise, Muswell Hill, N. ;
Capt. ARTHUR WILLSON M'KELLAR, 138 Leadenhall Street, E.C. ;
EVELYN NEVILLE PLEVINS, Woodford House, near Thrapston, Northants ;
Capt. SIDNEY PLUNKETT, West Hill House, Milton, Gravesend ;
THOMAS RULE, Kaombi, Chiromo, B.C.A. ;
Capt. ROBERT WILLIAM SCARFF, Tilbury Dock ;
Capt. W. SOPWITH SHELFORD, 80 York Mansions, Battersea Park, S.E. ;
EDMUND J. WALSH, 402 O'Connor Street, Ottawa, Canada ; and
Capt. ROBERT CAMPBELL WARDEN, 79 Mark Lane, E.C.,
were balloted for and elected Fellows of the Society.

THE PRESIDENT said : During the recess since the last Meeting of the Society in June its work has not been intermitted, and, apart from the usual routine, there are several points of interest which I think might be brought before the Fellows, however briefly, in commencing a new Session.

The Society was represented by an attractive exhibit at the Lincoln Show of the Royal Agricultural Society in the last week of June, and the opportunity was taken advantage of by a great many farmers and others attending the Show who had not previously seen a climatological station at work. Mr. Marriott gave several discourses on that occasion which aroused general interest ; and he has also continued the lectures to Local Scientific Societies from which such excellent results were obtained last year.

The efforts of the Society to advance the study of Meteorology in Schools and Colleges have not been relaxed, and a good deal of information on the subject has been acquired since our last meeting, the results of which will be presented to you before long. It has been decided to invite a competition amongst elementary School Teachers and others for the best specimen lesson on the Study of the Weather adapted for use in Schools ; but the most scrupulous Fellow need not fear that the Society is entering into rivalry with the " Limerick " press.

The Joint Kite Committee, in which the Society is associated with other

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bodies, has been extremely active, and has secured several series of ascents in connection with the International Co-operation in July and September last, some of the results of which will be placed before the Society this evening. The study of the Upper Air promises to be the most important contribution of the early part of the twentieth century to the science of Meteorology, and it is appropriate that the Symons Memorial Gold Medal of the Society for next year should have been awarded by the Council to M. L. Teisserenc de Bort, whose untiring efforts have been largely instrumental in leading to the splendid results now being obtained. It is gratifying to be able to announce that M. Teisserenc de Bort hopes to attend personally at the Annual Meeting in January to receive the Medal, and I am sure that he will be very heartily received.

It has been my privilege to represent the Society officially at the celebration of the Centenary of the Geological Society in September last, and to convey the congratulations of the students of weather to Sir Archibald Geikie, the master of weathering. I have also represented the Society on the Science Committee of the Franco-British Exhibition, and, together with several other Fellows of the Society, on the sub-committee which is organising the meteorological part of that important undertaking. Dr. Shaw, as Convener of the Sub-Committee on Meteorology, is carrying out the general arrangements, and we shall have the invaluable assistance of Mr. Marriott in arranging the details.

Some important changes have occurred in the Meteorological organisations of the Empire, chief amongst which I may mention the formation of a Federal Meteorological Department in Australia, and the revival of the Colonial Meteorological service in Jamaica under the charge of our colleague Mr. Maxwell Hall. It is pleasant to find that, after having been cared for Meteorologically for some years by the United States Weather Bureau, the leading West Indian Colony has resumed observational work on its own authority.

The succession of our old friend, Dr. Hellmann, to the Professorship of Meteorology in the University of Berlin and to the Directorship of the Prussian Meteorological Institute was only to be expected ; but we congratulate him none the less heartily upon the appointment.

The International Meteorological Committee, which has done so much in the past in promoting uniformity in the observations of different countries, has lost the services of its old President, M. Mascart, and its old Secretary, Prof. Hildebrandsson ; but we may feel a certain pride as a Society in the appointment of a member of our own Council, Dr. Shaw, to the Presidency of the International Committee ; and in the appointment of Dr. Hellmann as Secretary we have a further guarantee that the efficiency of the Committee will be in no way impaired by the change.

Dr. Shaw is continuing at the Meteorological Office those interesting conferences on important published meteorological papers which we have all learned to appreciate, and he is also delivering a course of lectures at the University of London upon "Meteorological Organisation and Methods." The improvement in the position of Meteorology as a University subject in this country is extremely gratifying ; but I regret to have to record a backward movement in the matter of the recognition of Meteorology at the Meetings of the British Association. It may be that this Society has been too considerate in not impressing upon the British Association the importance of the science and its claim to be represented in a section by itself or grouped with other branches of observational study. The unsatisfactoriness of the position of Meteorology in Section A at the last meeting has been commented on in several quarters, and we hope that some improvement will result in consequence.

I may refer to the prosperous state of the Society numerically, twenty-five names being down for election this evening, and thirty-seven for proposal as Fellows. The latter number is, I understand, the largest on any occasion in

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the history of the Society, and it is a personal gratification to myself to know that it contains the names of many rainfall observers who have long carried on valuable if unostentatious observations in that department of our science.

I would urge upon the Fellows the great importance of making an effort to improve the position of the Society still further as regards the number of members. Much of the work of such a Society as this depends upon the possession of an adequate annual income, and we have practically no other source of income than the contributions of Fellows. I believe that many suitable and desirable people are ready to join if they could only be sought out and made acquainted with the aims and advantage of the Society. A large membership has many advantages apart from the financial, and it is my hope that all the Fellows will take an increasing share in the work of the Society, and act zealously together in promoting all its efforts, confident that we are engaged in a branch of Science which is entering on a period of rapid advance.

The following communications were read :—

1. "The Registering Balloon Ascents in England of July 23-27, 1907." By W. H. Dines, F.R.S. (p. 1).

2. "Results of the Balloon Ascents made from Manchester, July 22-28, 1907." By J. E. Petavel, F.R.S., and W. A. Harwood (p. 5).

3. "Balloon Experiments in Dublin, July 22-27, 1907." By Professor W. E. Thrift, M.A. (p. 11).

4. "Discussion of the Meteorological Observations at the British Kite Stations, Session 1906-1907." By Margaret White, T. V. Pring, and J. E. Petavel, F.R.S. (p. 15).

December 18, 1907.

Ordinary Meeting.

Hugh Robert Mill, D.Sc., President, in the Chair.

Claud Andrew Allan, Darleith, Cardross, Dumbartonshire ;
Edward Heron Allen, 3 Northwick Terrace, N.W. ;
Allanson Bailey, Rothesay, Lemsford Road, St. Albans ;
Henry J. Bailey, J.P., D.L., Rowden Abbey, Bromyard ;
William Alcock Beck, B.A., Tower Bank, Sawrey, Ambleside ;
Charles Hugh Berners, J.P., D.L., Wolverstone Park, Ipswich ;
Charles Brown, J.P., Leycroft House, Weston-super-Mare ;
Miss L. H. Bushell, Hinderton Lodge, Neston, Cheshire ;
Charles Pratt Chambers, Orchard Head, Broughton-in-Furness ;
Harvey Ralph Goring Clarke, B.A., Brook House, Hayward's Heath ;
Alfred Clay, Darley Hall, Matlock ;
Humphrey B. Devereux, Waihi, New Zealand ;
Thomas Arthur Dickson, Sywell Hall, Northampton ;
James Dixon, J.P., Tylecote, Ranmoor, Sheffield ;
James William Duncan, The Firs, Castle Hill, Maidenhead ;
Rev. James Charles Fox, Temple Coombe, Somerset ;
Edward Pirie Gordon, J.P., Gwernvale, Crickhowell, Brecon ;
William Hall, Swerford, Enstone, Oxon. ;
Mrs. Marcus Hare, Court Grange, Newton Abbot ;
Joseph Hawksley, Assoc.M.Inst.C.E., 14 Albert Square, Great Yarmouth ;
Arthur Pearse Jenkin, F.S.I., Treevergie, Redruth ;
Charles Edwin Jones, Assoc.M.Inst.C.E., 31 Greycoat Gardens, S.W. ;
Owen Jones, Dollawell, Blaenau-Festiniog, N. Wales ;
Framjee Dorabjed Kapadia, Ahmedabad, Bombay Presidency, India ;

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Leonard G. King, 32 Palatine Road, Withington, Manchester;
Miss I. J. R. Macadam, 44 South Street, St. Andrews, N.B.;
William George Machin, Hartley Witney, Winchfield;
Philip Pennant Pennant, Nantlys, St. Asaph, Flintshire;
J. E. Petavel, F.R.S., University, Manchester;
Miss F. J. Sparks, Bincombe House, Crewkerne;
Albert John Stephens, 39 Denmark Road, Gloucester;
William Stead Strachan, B.Sc., 9 Victoria Street, S.W.;
Capt. Francis S. Symons, Kenilworth, Farnan Road, Streatham;
Arthur John Walker, M.A., Mount St. John, Thirsk;
Mrs. Wilkin, Summerhill, Tenterden, Ashford;
Miss E. D. Woodhouse, Burghill Court, Hereford; and
Miss J. L. Woodward, The Knoll, Clevedon, Somerset,
were balloted for and elected Fellows of the Society.

Mr. J. W. Forrester and Mr. T. P. Newman were appointed Auditors of the Society's Accounts.

The President said, that before proceeding with the papers, he could not refrain from giving expression to the feelings of all present at the immense loss to science sustained by the death of Lord Kelvin. He spoke the more feelingly because he knew how greatly Lord Kelvin had been interested in Meteorology, as in every other branch of physical science. He had the most catholic spirit of any scientific man in this country and of modern times, and he was interested in every scientific study, both as a man of science and as an eager and enthusiastic student of nature. Lord Kelvin's extraordinary youthfulness of character was perhaps the feature which first and always impressed every one who knew him. The last time he, Dr. Mill, had met Lord Kelvin, the latter had been speaking most enthusiastically about meteorological work in the recent Antarctic Expedition, and speculating on the origin of the Antarctic ice cap, and the nature of the land which it covered, as keenly as in the days long ago when he demonstrated the limit of possible thickness of the ice cap by the effect of pressure on the freezing point. He, the President, had had occasion to look up the names of William Thomson and Lord Kelvin in the Society's Bibliography of Meteorology, and there were so many entries that it would take too long to recapitulate them. Lord Kelvin's great work on Atmospheric Electricity was known to all, that on the Increase of Temperature within the Crust of the Earth was perhaps less remembered. By deductions drawn from the rate of cooling of the Earth, Lord Kelvin had reached back into the past and guessed at the beginning from the accumulated data of the present. He was always interested in the theory of Atmospheric Circulation, and keenly supported the claim of his brother, Professor James Thomson, to the priority of the statement of the atmospheric circulation, with which the name of Ferrel was more often associated in the text-books. Though the Society had, unfortunately, not been directly associated with Lord Kelvin, he, as President, could not allow the occasion to pass without referring to the irreparable gap made in the ranks of scientific men by the loss of Lord Kelvin, who summed up in himself so much of the history of physical science in the nineteenth century.

The following communications were read:—

1. "The Possibility of a Topography of the Air, based on Balloon Observations with special Theodolites." By Captain C. H. Ley, F.R.Met.Soc. (p. 27).

2. "Indications of Approaching Frost." By Richard Strachan, F.R.Met.Soc. (p. 47).

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CORRESPONDENCE AND NOTES.

Prize Competition for Teachers.

The Council of the Royal Meteorological Society, being desirous of encouraging the teaching in schools of facts regarding Weather and Climate, invite elementary teachers and others to send in essays on Weather or Climate in the form as given in the particulars below.

The Council are hoping by means of this competition to find out what kind of instruction on the subject of Weather is given to the scholars in the Elementary Schools. They believe that many teachers do impart much interesting and valuable information, and also help their scholars to keep records of the weather.

In the present competition the Council require that an original sketch of a Nature Study Lesson on Weather or Climate (not exceeding 1500 words) should be sent in, together with a brief summary of five other lessons to cover the whole subject of Weather and Climate.

It is desirable that the competitor should state for what Standard he (or she) considers the lessons to be suitable.

If essays of sufficient merit are received, three prizes will be awarded of £5, £3, and £2 respectively. All the competing essays will become the property of the Society, and the decision of the Council as to the awards shall be final.

The essays should be signed by the writer, and sent in on or before January 31, 1908.

Lectures on Meteorology.

Royal Meteorological Society.—During the past three months Mr. W. Marriott has given lectures on meteorological subjects in connection with the Society's scheme for diffusing a knowledge of meteorology at the following places:—

October 28.—Newcastle-on-Tyne, Literary and Philosophical Society.
November 1.—Brighton and Hove Natural History and Philosophical Society.
November 4.—Winchester, West Downs School.
November 14.—Keighley, Literary and Scientific Society.

Royal Geographical Society.—A course of six lectures on "The Geographical Distribution of Rainfall in the British Isles" will be given by Dr. H. R. Mill, in the Meeting Room of the Society, on Thursday evenings in January and February, beginning on January 23 at 6 p.m. The syllabus of the Lectures is as follows:—Lecture I. The physical geography of Great Britain and Ireland. Lecture II. Rain; its nature, origin, and functions. Lecture III. Measuring, recording, and mapping rainfall. Lecture IV. The duration and distribution of showers. Lecture V. Average annual rainfall; and Lecture VI. Rainfall in relation to configuration and economic conditions.

University of London.—A course of twelve lectures on "Meteorological Organisation and Methods of dealing with Meteorological Observations" is being given by Dr. W. N. Shaw, F.R.S., the Director of the Meteorological Office, and University Reader in Meteorology, at the University, South Kensington, on alternate Mondays at 5 p.m. The first lecture was given on October 21, 1907. The syllabus is as follows:—

METEOROLOGICAL OBSERVATION.—Instruments, observatories, and stations. Measurement of pressure, temperature, humidity, wind-velocity. Estimation and observation. Cloud forms and velocities. Methods of investigation of the upper air.

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METHODS OF DEALING WITH METEOROLOGICAL OBSERVATIONS.—Local differentiation and combination. Maps. Means and averages. Harmonic analysis. Periodicity. Correlation.

Cambridge University.—Mr. E. Gold will give a course of eight lectures in Meteorology, at the Cavendish Laboratory during Lent term, on Thursdays at 5 p.m., beginning on January 16. The syllabus is as follows:—

Lectures I. to IV., THERMO-DYNAMICS OF THE ATMOSPHERE.—Changes in a mass of air containing water vapour, which rises adiabatically or pseudo-adiabatically. The dry, rain, hail, and snow stages. The deductions of Hertz and von Bezold. Graphical representation. The potential temperature. Vertical temperature gradient deduced from kite and balloon observations. Formation of atmospheric waves. The changes produced by mixing quantities of air of different temperatures and humidities. Paradoxical result of mixing cold damp air with warm dry air. Methods of cloud formation. The solar halo.

Lectures V. to VIII., ATMOSPHERIC MOTION.—The general circulation. Theories of James Thomson, Ferrel, W. von Siemens, Oberbeck. Comparison with surface currents and with upper currents deduced from cloud observations. Distribution of isobars at higher levels. Local circulation. Relation between pressure-gradient and wind velocity. Characteristics of cyclones and anti-cyclones. Work of Diro Kitao. Formation of cyclones. Theories of Ferrel and Faye. Tropical cyclones and tornadoes. Theorem of Poincaré for angular velocity in symmetric atmospheric vortex. Results of upper air observations of wind velocity.

The Study of the Weather as a Branch of Nature Knowledge.

Dr. M. I. Newbigin recently delivered a lecture on this subject to classes of teachers at Aberdeen and Edinburgh, which is printed in full in the *Scottish Geographical Magazine* for December 1907. This is an interesting Nature Study Lesson, very much on the lines suggested by the Council of the Royal Meteorological Society.

Dr. Newbigin says:—"In endeavouring to suggest to you methods of studying the weather in schools as a part of nature knowledge, it may be well to begin by considering very briefly the aims which should inspire a course in nature study, for our methods will be naturally largely influenced by our aims. The object of such a course is, I take it, twofold. We want, in the first instance, to train the powers of observation and develop the intelligence, with the view not only of making better citizens, but also of increasing the happiness of life; and, in the second place, we want to give an insight into the methods of science. To show that the methods of science are everywhere in essence the same, and to suggest that, owing to the fact that the further scientific research is carried, the more obvious it becomes that nature is orderly and uniform, and that there are, therefore, few series of phenomena too trivial to be worth study by some one—these, in my opinion, are points of great and increasing importance. Again, even elementary education is incomplete unless it succeeds in imparting some flavour of real enthusiasm for science.

"When we come to practical detail I suppose most of you, as practical teachers, have felt that the supreme difficulty is to find what we may call a jumping-off point. I heard the other day an interesting story of a little girl who objected strenuously to going to school, because, as she said with much force, 'They don't teach me anything I want to know.' This is probably a condition that frequently occurs, but in the teaching of such subjects as arithmetic and spelling we have behind us the driving force of parents and relatives who say, with a truth that even the child recognises, that adult life is impossible without a certain amount of knowledge. In nature study in

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general we have not as yet this advantage, and have even to allow for the fact that the parent in the background is probably saying, 'Tadpoles and dandelions are all very well, but that won't help you to earn your living.' It is, therefore, very important to include in the course subjects about which the child does want to know, in which there is an initial interest to help us over the drag at the start. Now the weather is our basal subject of conversation, interests us at every turn of life, and as even the child feels this interest, the subject is one well worthy of the attention of teachers of nature study. Again, the uncertainty of our weather has become a proverb, the difficulties of forecasting not less so, and yet when we study weather in detail, we find that, although we can say very little as to the possible weather next week, and almost nothing as to its probable course next month, yet the annual series of changes which make up the climate of a locality take place in orderly sequence, and almost all the elements of the total are more or less fixed and constant. The fact that from one point science means the finding of order in apparent chaos may thus be well brought out. One must not also forget that the child is eminently practical and utilitarian, and we are not only all naturally interested in weather, but in a maritime country it is of great practical importance. In a coast town like Aberdeen one has the coastguard station as an evidence of this practical interest, and one can even hope to show that coastguard station, *Nautical Almanac*, and Meteorological Society form a sequence, illustrating the fact that science is merely enlightened and developed common sense and common experience."

Dr. Newbigin then proceeds to give an interesting and simple lesson on the study of the weather. He concludes as follows:—

"My aim in this lecture has been both to show what there is to teach in connection with weather, and to suggest methods of teaching it. As is the case in practically all the sciences, the great difficulty is to combine in a rational way the method of direct observation and of instruction, so as to give the taught something in the way of a practical appreciation of the subject. If I may recapitulate my suggestions, I should say, begin first by the most general and simple observations of wind and sky, sunshine and rain. Then introduce the barometer, and get a series of observations sufficient to answer a series of questions, such as: Does the barometer move or not? much or little? does the wind affect it? the temperature? rain? At first, at any rate, I should be disposed to let the class take observations for a school week at irregular intervals rather than continuously, and then let them compare different weeks until they gradually acquired some notion of the meaning of average height. After the interest had been aroused it would be a good plan to give a series of more detailed lessons, and gradually introduce the consideration of cyclones and anticyclones, the reading of weather charts, and so forth. One would naturally take advantage of outstanding meteorological events as texts—a great storm such as that which wrecked the *Berlin*, a long frost, our late fine Easter: any one of these would form an interesting starting point. As I have tried to show also, the subject may be correlated in many different ways with the ordinary geography lesson, or even with history, for climate has had much to do in making the British what they are, and climate is merely the average succession of weather. Especially, however, I should lay stress upon the attempt to employ meteorological phenomena as a stimulus to the imagination, and I should urge the value of introducing in occasional lessons conceptions which in their entirety may be beyond the reach of the class, but of which they can be made to understand enough to greatly interest them. I have great faith in Anatole France's dictum that a child's feelings may be intensely roused by subjects which are, strictly speaking, beyond his intellectual reach. I should strive to make clear, for instance, something of the romance

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of a meteorological map, to picture the many patient observers, widely separated from one another, who, day by day, records each his quota of facts—facts whose full significance the individual cannot at the time fully see, but which he registers in the certain knowledge that they will fit into a clear and coherent whole. Man, now no more than ever he could, can alter the course of the winds, but within limits he has now so far conquered nature that he can tell whither they come and where they will go, he has conquered time and space so far that he can send warnings of coming changes. Here, surely, are facts which are worth knowing, suggestions which are worth making. Again, though the meteorological map is an extraordinary triumph of skill, it has still many gaps. The meteorologist is still groping after that perfection of his methods which will enable him to prophesy without any fear of error, and his science has not the frigidity of perfection, but the perennial interest of an evolving organism. In our own British weather maps, so apparently a trifling matter as the opening of the cable to the Faröes and Iceland has greatly increased the value of the forecasts.

"I do not wish to claim for the study of the weather any monopoly of merit, but only to suggest that if I am right in my statement of the aims which should prompt the teacher of nature study, it is a branch which is well fitted to carry out these aims."

RECENT PUBLICATIONS.

Meteorology in Mysore for 1906, *being the Results of Observations at Bangalore, Mysore, Hassan, and Chitaldrug.* Fourteenth Annual Report. By JOHN COOK, M.A., F.R.S.E. Bangalore, 1907. 4to. 18 + 122 pp. and 9 plates.

In addition to the usual information given in these annual Reports, the present volume contains a set of tables of "Daily Means" for the twelve years 1893-1904, for each of the four Observatories at Bangalore, Mysore, Hassan, and Chitaldrug. In accordance with the recent action of the Government of India, which has reduced the great majority of its second-class observatories to third-class ones, the Hassan and Chitaldrug observatories will for the future be of the third class, and will therefore record merely the 8 a.m. observations daily.

The Climate of Abbassia near Cairo. By B. E. F. KEELING. Survey Department paper, No. 3. Cairo, 1907. 61 pp. and 8 plates.

This is a summary of 35 years' observations made at the Observatory, which was founded in 1868, principally for meteorological work, by the Khedive Ismail Pasha. The Observatory was maintained continuously at Abbassia till the end of 1903, when it was removed to Helwan. Since that date a second order meteorological station has only been continued at Abbassia. Previous summaries of the work of this Observatory have from time to time appeared, viz. a very detailed paper, "Notice sur le Climat du Caire," published by M. J. Barois in 1889, in the *Bulletin de l'Institute Égyptien*, and a summary of 30 years' observations in the *Annual Meteorological Report of the Survey Department* in 1898-1899. After the date of the latter of these summaries there were 5 years' observations before the removal of the Observatory, and in the paper under notice a summary of these 5 years' observations and the mean values for the 35 years are given. It has not been possible to treat the results in a homogeneous manner, owing to the fact that the instrumental equipment

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has not been uniform. The results have been summarised as far as possible in the form of tables, the descriptive part being confined to the limits necessary for explaining them. Summarised climatological tables are given, and for each of the principal meteorological elements necessary for corrections, to reduce the means deduced from the present readings made three times a day to the true daily mean published before the closing of the Observatory, are given. The paper also contains charts showing the annual and daily curves obtained for each of the principal elements. The following table shows the mean results for 17 years, 1887-1903 :—

MEANS OF CLIMATOLOGICAL OBSERVATIONS AT ABBASSIA, CAIRO, 1887-1903.

MONTHS.	Temperature.						Relative Humidity.[2]	Rain.
	Means.				Extremes.			
	Min.	Max.	Range.	Mean.[1]	Min.	Max.		
	°	°	°	°	°	°	%	in.
January	44·2	64·9	20·7	54·1	30·7	79·9	68	·27
February	46·8	69·6	22·8	56·8	34·2	95·9	64	·16
March	50·0	75·6	25·6	62·4	37·8	106·2	58	·16
April	55·0	83·7	28·7	70·2	42·3	108·7	50	·08
May	60·8	90·9	30·1	76·8	48·2	111·6	46	·04
June	65·1	95·2	30·1	81·9	56·7	113·4	46	...
July	69·4	97·2	27·8	83·5	60·8	111·7	50	...
August	69·4	94·8	25·4	82·6	59·9	106·9	55	...
September	66·0	90·0	24·0	78·1	56·3	105·1	61	...
October	62·8	86·0	23·2	73·2	51·4	107·8	65	·04
November	54·3	75·7	21·4	65·1	38·3	92·5	66	·20
December	48·2	68·4	20·2	57·9	34·3	84·9	70	·23
Year	57·7	82·7	25·0	70·2	30·7	113·4	58	1·18

[1] 35 years, 1869-1903. [2] 33 years, 1871-1903.

The Rainfall of the Philippines. By the Rev. M. S. MASO. Prepared under the direction of the Rev. J. ALGUÉ, S.J., Director of the Weather Bureau, Manila, 1907. 4to. 32 pp.

This statement of rainfall in the Philippine Archipelago was prepared in 1905 at the request of the Solar Commission. Except for Manila, whose uninterrupted records extend back to the year 1865, and for a few other stations which have reported the rainfall during ten or more years, there has not been a very extensive series of observations to work on. Considering, however, the relative small area of the Archipelago, the data given in the paper convey a very fair idea of the nature and variation of the rainfall in the Philippine Islands. Detailed results of monthly rainfall at sixty-four stations for varying periods are given, and the subject is dealt with under the following heads :—

1. Summer and autumn rainfall ; cyclonic rainfall.
2. Winter or north-east monsoon rainfall ; and
3. Spring rainfall : March, April, May.

The mean yearly amount of rainfall is really high in the whole Archipelago, but its effect depends principally upon its distribution throughout the year. In respect to rainfall, three different climates can be distinguished in these islands.

The first, and worst of them, has two well-defined seasons, wet and dry. This climate prevails in those regions which during the summer months

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receive more than 80 per cent of the annual rainfall, and consequently have five rainy months and practically seven of drought. Such regions are those facing the China Sea, the low plains extending northward and eastward from Manila Bay, the moderately high and hilly lands surrounding these plains, and the part of the provinces of Luzon, facing the southern seas with mountains to the north. The same climate is found also in some valleys and plateaus extending along the central mountain range of Luzon, as Baguio (4780 feet above sea-level).

The second climate consists of eight or nine months of rain and three or four of drought, the percentage of rainfall being high during both the summer and winter season. This climate prevails in the eastern and south-eastern parts of Luzon, and in the central Visayas, where the North-easters blow almost without any obstacle.

The third and best climate is that which results from a fairly even distribution of the rainfall over the whole year, and consequently shows a quite uniform percentage for the three different seasons—summer and autumn, winter, and spring months. This climate is found south of the fourteenth parallel only, being enjoyed by some regions of south-eastern Luzon, the eastern Visayas, Mindanao, and Jolo. The western part of Mindanao, as is shown by the records of Zamboanga, is the region of the whole Archipelago which receives the smallest amount of annual rainfall; but this deficiency is largely counterbalanced by a fairly regular distribution, so much so, that the tropical climate of Zamboanga is considered as one of the best in the Archipelago.

In the island of Luzon, the province of Nueva Vizcaya, situated about 1300 ft. above sea-level, has only 26·7 ins. of annual rainfall, but this is very well distributed. The adjacent wide and long valley, comprising the provinces of Isabela and Cagayan, has likewise a fairly good distribution, in fact far better than that in the western provinces of Luzon. The rainfall distribution at Baguio, 4780 ft. above sea-level, must be regarded as rather abnormal, due to some peculiar local conditions, because it really differs from that observed in the other highlands of the Archipelago.

A few stations which have a very great and quite abnormal annual rainfall must be mentioned. These are Masinloc, on the Zambales coast of Luzon, facing the China Sea, with 157 ins.; Mamburao, on the western coast of Mindoro, with 125 ins.; and Tandag, on the eastern coast of Mindanao, with 174 ins. Although these averages are based on the observation of only two years, they are considered to be sufficiently reliable, owing to the special local conditions of these stations. Masinloc is situated at the head of a large bay open to the China Sea. At a distance of a few miles to the east a rather steep mountain range, some 4000 ft. high, runs in a north to south direction. Hence the district receives the full force of the Western and South-western winds, which, striking the near-by slopes, take an ascensional movement, and discharge the immense amount of moisture which they hold upon the narrow strip of land and the mountain slopes. The location of Mamburao is very much like the one just described. Tandag lies likewise at the head of a bay, which is rather small, open towards the north-east, and surrounded by hills covered with dense forests. The moist North-east winds rush into the funnel-shaped opening, take an ascending direction, and discharge the greater part of their moisture as abundant precipitation.

The following is a summary of the different climatic zones of the Archipelago:—

1. Zone of very definite rainy and dry seasons:—

The western coasts of Luzon, from Cape Santiago to Cape Bojeador, including the western part of Manila Bay; the western coasts of Mindoro and Panay

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and the Calamianes group; the central plains and moderately high lands of Luzon, from Batangas to Nueva Ecija and Pangasinan; the region of Benguet. The yearly amount of rainfall is above 80 ins. in the western section and in Benguet, while in the central section it is between 60 ins. and 80 ins.

2. Zones or regions with long rainy season, including the summer, autumn, and winter months, and consequently with a very short dry period :—

The northern and eastern coasts and the south-eastern part of Luzon, including the Cagayan and Isabela valleys; Batanes and Babuyanes Islands; the central Visayas, as Romblon, western Cebu, northern Panay, and Negros; the northern part of Mindanao. The annual amount of rainfall is very great, above 120 ins. in northern Panay; above 80 ins. in northern and eastern Luzon, Batanes, and Babuyanes islands, northern Negros, and Romblon; moderate, that is, below 80 ins., in the Cagayan valley of Luzon and in northern Mindanao.

3. Zones with more or less uniform distribution of rainfall over the whole year :—

The south-eastern end of Luzon; the eastern Visayas, Masbate, Samar, Leyte, Bohol, Camiguin, eastern Cebu, eastern and southern Negros and Panay; the eastern and southern coasts of Mindanao; Basilan and Jolo; the relatively high and hilly province of Nueva Vizcaya in Luzon. Within these regions the annual rainfall surpasses 120 ins. in some coast stations of south-east Luzon, eastern Samar, and Mindanao. In the rest it varies between 80 ins. and 120 ins., except in eastern Cebu, south-west Leyte, southern and central Mindanao, Basilan, Jolo, and Nueva Vizcaya in Luzon, where the yearly amount remains below 80 ins.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of more general interest.

A[bbe], C.—The Fundamental Interval in Meteorological and Climatological Studies, especially in Charts of Isohyetal Lines. *Monthly Weather Rev., Washington*, **35**, 1907 (306-310).

Aitken, J.—Hygroscopes. *Symons's Meteor. Mag., London*, **42**, 1907 (187-188).

[Baden-Powell, B.]—Fog Dispersion. Facts and Fallacies, by the Editor of "Knowledge." *Daily Graphic, London*, Nov. 12, 1907.

Barus, C.—On Distribution of Nuclei in dust-free wet Air, and on Methods of Observation. *Proc. Amer. Phil. Soc., Philadelphia*, **46**, 1907 (70-79).

Bates, Rev. D. C.—The Study of Weather Phenomena. *Symons's Meteor. Mag., London*, **42**, 1907, (117-129; 198-202).

Belden, W. S.—Special Temperature Observations made on Low Ground in the Vicinity of Vicksburg, Miss. *Monthly Weather Rev., Washington*, **35**, 1907 (219-221).

Bentley, W. A.—Studies of Frost and Ice Crystals. *Monthly Weather Rev., Washington*, **35**, 1907 (348-352).

Bigelow, F. H.—Studies on the Phenomena of the Evaporation over Lakes and Reservoirs. *Monthly Weather Rev., Washington*, **35**, 1907 (311-316).

Birdwood, Sir G.—The Mechanism of the South-West Monsoon. *J. Soc. Arts, London*, **55**, 1907 (1070-1072).

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Birdwood, Sir G.—The Phenomenon of the South-West Monsoon. *J. Soc. Arts, London*, **56**, 1907 (33-35).

Bonacina, L. C. W.—The Effects of Exposure to Wind upon the Amount of Rain caught by Rain-Gauges, and the Methods of protecting Rain-Gauges from them. *British Rainfall*, **1906**, *London*, 1907 (27-45).

Bonacina, L. C. W.—Rain-Gauge Exposure and Protection. *Nature, London*, **76**, 1907 (672-673).

Bonacina, L. C. W.—On some of the Causes and Effects of Atmospheric Electricity. *Symons's Meteor. Mag., London*, **42**, 1907 (169-174).

Bonacina, L. C. W.—On a Representation of the Temperature Cycle of the Seasons. *Symons's Meteor. Mag., London*, **42**, 1907 (191-194).

B[ryant], W. W.—The alleged Summer of 1907. *Observatory, London*, **30**, 1907 (379-381).

Chauveau, A. B.—Sur le climat de Hanoi. *Ann. Soc. Mét. France, Paris*, **55**, 1907 (166-175).

Chree, C.—Auroral and Sun-Spot Frequencies contrasted. *Proc. Physical Soc., London*, **20**, 1907 (434-452).

Coblentz, W. W.—Barnes's Ice Formation with special Reference to Anchor Ice and Frazil. *Monthly Weather Rev., Washington*, **35**, 1907 (225-227).

Coffey, G. A.—Influence of Temperature and Moisture upon the Rate of Growth of Tobacco. *Monthly Weather Rev., Washington*, **35**, 1907 (346-348).

Cottier, J. G. C.—A Summary of the History of the Resistance of Elastic Fluids. *Monthly Weather Rev., Washington*, **35**, 1907 (353-356).

Curtis, R. H.—The Distribution of Sunshine over the British Isles. *Symons's Meteor. Mag., London*, **42**, 1907 (147-151 and pl.).

Cyran, G.—Die Trockenheit des Jahres 1893 in Mitteleuropa. *Wetter, Berlin*, **24**, 1907 (182-186, 203-207).

Dike, P. H.—Paulsen's Resumé of Recent Theories of Polar Lights. *Terrestrial Magnetism and Atmospheric Electricity, Baltimore*, **12**, 1907 (84-86).

Dobrowolski, A.—Les cristaux de glace aériens et le phénomène des halos. *Ciel et Terre, Brussels*, **28**, 1907 (305-312, 336-342).

Eliot, Sir J.—A Discussion of the Anemograph Observations recorded at Allahabad from September 1890 to August 1904. *Memoirs, Indian Met. Dept., London*, **18**, 1907 (283-371 and 13 pl.).

Eliot, Sir J.—A Discussion of the Anemographic Observations recorded at Lucknow from July 1878 to October 1892. *Memoirs, Indian Met. Dept., London*, **18**, 1907 (373-430 and 15 pl.).

Fassig, O. L.—Guilbert's Rules for Weather Prediction. *Monthly Weather Rev., Washington*, **35**, 1907 (210-211).

Feuvrier, Dr.—Sol et climat du Monténégro et météorologie du Plateau de Tsetigne. *Ann. Soc. Mét. France, Paris*, **55**, 1907 (153-160).

Fischer, K.—Die Verbreituug von Nachrichten über die Wasserstands- und Eisverhältnisse der Flüsse durch den öffentlichen Wetterdienst in Norddeutschland. *Wetter, Berlin*, **24**, 1907 (169-174, 196-198, 217-220).

Forbes, N. H.—The Shropshire Highlands. Church Stretton as a Climatic Health Resort and "After-Cure" Station, with Brief Notes on the Wentnor Saline Water. *Baln. Clim. J., London*, **11**, 1907 (260-279 and pl.).

Gerstmann, H.—Zur Frage einer Wetterscheide in den Alpen. *Wetter, Berlin*, **24**, 1907 (174-178, 198-200, 220-232).

Gheury, M. E. T.—Observations of Halos and Coronas in England. *Monthly Weather Rev., Washington*, **35**, 1907 (213-215).

Gorczynski, L.—Influence of the Glass Cover on Actinometric Thermometers. *Monthly Weather Rev., Washington*, **35**, 1907 (358-361).

Guilbert, G.—Principles of Forecasting the Weather. *Monthly Weather Rev., Washington*, **35**, 1907 (211-212).

Henry, A. J.—The Cold Spring of 1907. *Monthly Weather Rev., Washington*, **35**, 1907 (223-225).

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Henze, H.—Beziehungen zwischen den Mittel- und Scheitelwerten der Windgeschwindigkeit in Potsdam. *Meteor. Zeits., Brunswick*, **24**, 1907 (394-405).

Homma, Y.—Distribution of Electricity in the Atmosphere. *Terrestrial Magnetism and Atmospheric Electricity, Baltimore*, **12**, 1907 (49-72).

Klengel, F.—Die Niederschlagsverhältnisse von Deutsche-Südwestafrika. *Wetter, Berlin*, **24**, 1907 (178-181, 201-203, 282-237).

Knoche, W.—Die äquivalente Temperatur ein einheitlicher Ausdruck der klimatischen Faktoren "Lufttemperatur" und "Luftfeuchtigkeit." *Meteor. Zeits., Brunswick*, **24**, 1907 (433-444).

Lancaster, A.—L'humidité de l'air en Belgique. *Ann. Météor., Brussels*, 1907 (119-247 and 3 pl.).

Lancaster, A.—Le climat de la Belgique en 1905. *Ann. Météor., Brussels*, 1907 (373-604 and 3 pl.).

Langbeck, K.—Studie über Wirbelgewitter nach Beobachtungen am 20. Februar, 1907. *Meteor. Zeits., Brunswick*, **24**, 1907 (444-453 and pl.).

Leal, M.—Correlación de los vientos en León, deducida de ocho años de observación, de 1898 à 1905. *Mem. Soc. Cient. Antonio Alzate, Mexico*, **24**, 1907 (327-329 and 2 pl.).

Legal Decisions as to Cyclones. *Monthly Weather Rev., Washington*, **35**, 1907 (260-261).

Leyst, E.—Ueber Schätzung der Bewölkungsgrade. *Bull. Soc. Imp. Natur., Moscow*, **1906** (217-269).

Leyst, E.—Meteorologische Beobachtungen in Moskau im Jahre 1906. *Bull. Soc. Imp. Natur., Moscow*, **1906** (402-442).

Lockyer, W. J. S.—Multiple Lightning Flashes. *Knowledge, London*, **4**, 1907 (217-221).

McAdie, A. G.—Klimatologie von Kalifornien. *Meteor. Zeits., Brunswick*, **24**, 1907 (453-461).

Maring, D. T.—The Jamaican Weather Service. *Monthly Weather Rev., Washington*, **35**, 1907 (317-319).

Marriott, W.—International Investigation of the Upper Air. *Symons's Met. Mag., London*, **42**, 1907 (154-156).

Martin, E. A.—Dew Ponds, Supplementary Remarks. *Knowledge, London*, **4**, 1907 (197).

Meissner, O.—Bewölkung und Sonnenschein in Potsdam (1894 bis 1900). *Meteor. Zeits., Brunswick*, **24**, 1907 (406-417).

[Mill, H. R.]—The Christmas Snowstorm of 1906. *British Rainfall*, **1906**, *London*, 1907 (19-26).

Mill, H. R.—The Drought of September, 1907. *Symons's Met. Mag., London*, **42**, 1907 (167-168).

[Mill, H. R.]—The Rainfall of October 1907. *Symons's Met. Mag., London*, **42**, 1907 (189-191).

Moore, Sir J. W.—The Climatology of Ireland in relation to the Public Health. *J. R. Sanit. Inst., London*, **28**, 1907 (363-371).

Morrison, J. H.—The St. Swithin's Day Fallacy. *Monthly Weather Rev., Washington*, **35**, 1907 (274-276).

Nansen, Dr. F.—On North Polar Problems. *Geog. J., London*, **30**, 1907 (469-487 and pl.).

Nouailhac-Pioch et Maillet, E.—Sur le débit probable des sources du Bassin de la Seine pendant la saison chaude de 1907 (1er Mai—1er Novembre), et sur la sécheresse de la saison chaude 1906 en France. *Ann. Soc. Mét. France, Paris*, **55**, 1907 (137-140).

Peppler, W.—Starke Niederschläge und ihre Ursachen. *Wetter, Berlin*, **24**, 1907 (210-215).

Pettersson, O.—On the Influence of Ice-melting upon Oceanic Circulation. *Geog. J., London*, **30**, 1907 (273-295).

Phillips, W. F. R.—Relation of Temperature, Humidity, and Winds to Chronic Nephritis. *Balneol. Clim. J., London*, **11**, 1907 (280-285).

Polis, P.—The new Public Weather Service of Germany. *Monthly Weather Rev., Washington*, **35**, 1907 (364-366).

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Quin, J. T.—The Relation of the Movements of the High Clouds to Cyclones in the West Indies. *Monthly Weather Rev., Washington*, **35**, 1907 (215-218).

Reeder, G.—Observations of Halos at Columbia, Mo. *Monthly Weather Rev., Washington*, **35**, 1907 (212-213).

Richardson, H. W.—Relations of the U.S. Weather Bureau to the Railroad Man, *Monthly Weather Rev., Washington*, **35**, 1907 (259-260).

Rotch, A. L.—Resolutions adopted at the Milan Conference for Scientific Aeronautics. *Monthly Weather Rev., Washington*, **35**, 1907 (210).

Schwalbe, G.—Über "Niederschlagstypen" und ihren Einfluss auf die jährliche Periode des Niederschlages. *Meteor. Zeits., Brunswick*, **24**, 1907 (385-393).

Strachan, R.—On Hygrometers. *Horological J., London*, **49**, 1907 (150-151, 165-168, 184-186, 205-206).

Taylor, N. R.—Climatology of Springfield, Mo. *Monthly Weather Rev., Washington*, **35**, 1907 (265-267).

Teisserenc de Bort, L.—Sur la distribution de la température dans l'atmosphère sous le cercle polaire nord et à Trappes. *Ann. Soc. Mét. France, Paris*, **55**, 1907, (140-143).

The Franco-American Expedition to explore the Atmosphere in the Tropics. *Aeronautical J., London*, **9**, 1907 (62-65).

The Meeting of the British Association. Discussion on Modern Methods of treating Observations. *J. R. Statistical Soc., London*, **70**, 1907 (471-476).

Tittmann, O. H.—The Magnetic Observatories of the United States Coast and Geodetic Survey. *Terrestrial Magnetism and Atmospheric Electricity, Baltimore*, **12**, 1907 (73-76).

Tizard, T. H.—Dr. Otto Pettersson on the Influence of Ice-Melting on Oceanic Circulation. *Geog. J., London*, **30**, 1907 (339-344).

Vincent, J.—Les ascensions de ballons-sondes en Belgique. *Ann. Météor., Brussels*, **1907** (248-279 and pl.).

Walter, A.—Drought in Mauritius. *Knowledge and Illustrated Scientific News, London*, **4**, 1907 (198-200).

Westman, J.—Mesures de l'intensité de la radiation solaire faites à Upsala en 1901. *K. Svenska Vetenskapsakademiens Handlingar, Stockholm*, **42**, 1907, No. 4.

Westman, J.—Durée et grandeur de l'insolation à Stockholm. *K. Svenska Vetenskapsakademiens Handlingar, Stockholm*, **42**, 1907, No. 6.

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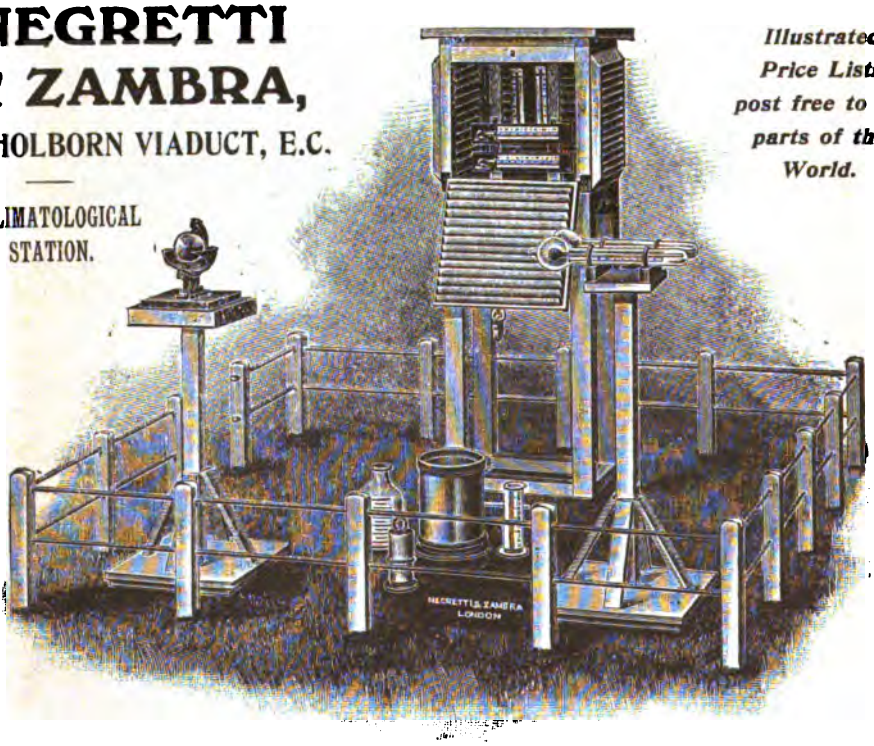
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VOL. XXXIV.] APRIL 1908 [No. 146

MAP-STUDIES OF RAINFALL.

BY HUGH ROBERT MILL, D.Sc., PRESIDENT.

[An Address delivered before the Royal Meteorological Society, January 15, 1908.]

(Plate 1.)

IT is good for a Society to have a wide range of selection when appointing a President for the year, and a kindly provision which gives the occupant of the chair a second chance, so that learning by experience he may haply make a wiser use of his opportunities after the first term. Amongst the past Presidents—not a few of whom are happily present—there have been men of distinction in many walks of life to whom the science of meteorology appealed in various ways. On examining the list of the twenty-eight previous Presidents (for though there were thirty previous presidentships two served the office twice) one finds that they were as nearly equally divided as the total number will permit between astronomers, medical men, engineers, professed meteorologists, and others. This gives variety and the advantage of numerous points of view, for the subject and treatment of the address necessarily depend largely on whether meteorology was to the President of the year the matter of his daily work, a science related to that which he pursued, an aid in the study of his profession, or the delight of his leisure hours. From each point of view it is possible to see some special aspect of meteorology in a fresh light and in a way that appeals more forcibly than any other to particular minds.

Last year my predecessor opened to us a fascinating chapter of history illuminated, or as often overshadowed, by the influences of weather. That address appealed delightfully to every one save only the unhappy President-designate, who well knew that he could not bring forth from his treasury things new or old so pregnant with human interest.

Belonging as I do to those who spend their whole time in meteorological work, I suffer to the full from the curse of the specialist—want of

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time to keep abreast of the contemporary progress of his own science as a whole. Hampered by routine—which must be fulfilled at fixed dates,—one in my position finds that opportunities of conducting researches, pondering over generalisations, or following out lines of thought, even in his own department, occur rarely and in fragments. Such a position predisposes to the torture of Tantalus. To live by a swirling stream of data that one can scarcely keep in its channel; to see lines of fruitful investigation open up and wheel aside like the furrows of a ploughed field from a railway carriage; to realise with each recurring year that the new harvest being gathered in is only adding to the store which is never being fully utilised,—is enough to make the most fastidious purist in language mix his metaphors.

I can only speak on such an occasion as this of my own work, for it leaves me no time to look at other things, and hence I invite you, though with some misgivings, to enter the rather rough and infertile corner of the great field of meteorology which I till, and to see something of the methods which appear likely to lead to its improvement. The specialist situated as I have indicated can at least claim one advantage over the student of many books, and that is no small one, for he learns to test his data before using them and to misdoubt the conclusions of others before testing them.

I must speak of rain, and even then only of the rain that falls from the currents and eddies of air that drift across these islands lying between the Continent and the deep sea. The special problem I have before me (which I greatly fear I may have to leave unsolved behind me) is to determine the normal annual rainfall of the British Isles in relation to the general configuration of the land, and to ascertain how the rainfall of individual years and months, and even of the constituent showers, is related to the normal.

The most useful method of working towards this end is by the preparation and study of maps of rainfall, and as that method is not yet familiar to the public, or even to some persons interested in meteorology, I propose to attempt in this address to deal with map-studies of rainfall. Time has not come my way to allow of the preparation of a complete memoir, and I can present this only as a fragmentary contribution to cartometric hyetography.

The map as a means of meteorological expression has been greatly used by the weather services of all countries, and by none more effectively than by our own Meteorological Office. I can claim novelty for nothing I have to say, but novelty is not the only element of interest or of value on such an occasion as the present.

Rainfall maps are by no means new, and a good deal has been written on the principles which ought to guide their construction. A historical review of the subject does not come into the present scheme, and is not omitted accidentally. One or two preliminary points have to be touched on. Isohyetal lines, *i.e.* lines which divide two contiguous areas in one of which the rainfall is lower and in the other higher than a given amount, are precisely similar to contour lines of level, or isobars or isotherms. The only difference in constructing a rainfall map and a map of temperature or pressure is that no correction for elevation above sea-level has to be applied, the rainfall depths being referred to the

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actual surface of the land at the place of observation; so that the colouring of a rainfall map appeals directly to the eye, presenting the actual conditions without any qualification, and requiring no mental correction as a pressure or temperature map does.

The distribution of rainfall is to a large extent dependent on the local configuration of the land, and, therefore, it is necessary to have a far greater number of points from which to construct a map of rain than in the case of pressure, which is an affair of the air alone, or of temperature on which the influence of land is less dominant.

Thanks to the remarkable insight and unflagging diligence of the late Mr. G. J. Symons, the number of observers of rainfall in the British Isles has increased from a few hundreds in 1860 to more than 4500 at the present time. These observers are actuated by many motives; but the work being done for their own purpose, they all send in their records to the historic Rainfall house in Camden Square, where Symons brought the British Rainfall Organisation to maturity, and where all the records collected by him and since his time are preserved for reference. A few of the records received every year are bad, a considerable number indifferent, but the vast majority are of surprising excellence, showing an amount of vigilance and conscience that do honour to the community. Every record that is received is critically examined, and many errors are detected and corrected as a result of the comparison of one record with its neighbours. The total annual rainfall is published in *British Rainfall*, and various aspects of the fall of rain in space and time are discussed with some detail. It is not necessary to refer at present to these discussions. They are conducted on the broad lines laid down by Mr. Symons, and where they have varied from the traditional mode of treatment it is mainly by the development of cartographic and cartometric methods.

The material for map studies of British rainfall is contributed by the thousands of observers past and present, whose organised and united work forms a vast structure of mutually supported facts such as it falls to the lot of few men of science to deal with. To these observers students of meteorology owe a debt that we can scarcely realise, and are quite powerless to acknowledge adequately; but it is impossible for me to touch on this subject before this audience without offering the tribute of the fullest recognition to the rainfall observers of the country.

When the philosopher Kant divided the communication of experience into two categories: the historical or relation in order of time, and the geographical or relation in order of space,—he suggested the two methods of treating all natural phenomena subject to variation in different places at the same time, and at different times in the same place. The historical method of studying rainfall is the more attractive, for it leads us into the temptation of endeavouring to project the light of the past upon the future, and by observing former recurrences of wet and dry periods to predict what the next year or month will bring forth. I do not say that this path of research should not be pursued, but it is both difficult and dangerous. Although even cycle-hunts are not to be discouraged when the scientific sportsman is gifted with a critical and unbiassed mind, at present I am only treading the safe and unadventurous path of geographical distribution, and I think there are reasons for believing

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that that path may lead us far towards more than one important conclusion.

In considering the distribution of rainfall, as in considering any other problem scientifically, we require to use terms with a definite meaning, and I hope that I may be excused for assigning definite meanings to familiar English words instead of importing classical terms which, despite a grander display of syllables, can mean no more. For convenience I use the term *mean* as indicating the sum of any number of figures divided by that number, reserving the word *average* for the mean of a number of figures representing values in order of time. Thus the mean of thirty annual rainfall values is spoken of as the average rainfall for thirty years. The mean of a number of uniformly distributed figures representing the distribution of rainfall in space I speak of as the *general* rainfall of the area concerned; thus the mean depth of rainfall over England for any day, month, or year, is the *general rainfall* of England for that particular day, month, or year. The mean of the general rainfall of England for thirty years is expressed as the *average general rainfall* of England for thirty years. A line passing through points having the same rainfall is an isohyetal line, or *isohyet*—the term having been already introduced is retained on account of its similarity to isotherm and isobar. The line joining successive positions of the centre of an atmospheric depression or cyclone is the *track* of the depression. The isohyetal lines representing the distribution of rainfall in a shower may be termed the *splash* of the rainfall, and the isohyets representing the rainfall of one or several days for a considerable stretch of country along the track of a depression, which is the generalisation of a succession of splashes, may be called the *smear* of the rainfall of that depression. These are all the special terms which it will be necessary to use.

The map which forms the basis of any work on the geographical method must, of course, be accurate and expressive. Fortunately we have in the work of the Ordnance Survey a basis of unimpeachable accuracy reproduced on a great variety of scales. The six-inch map is rarely required in rainfall work, except for the purpose of ascertaining the altitude of stations above sea-level, and the one-inch map is useful mainly in fixing the exact position of gauges. For the purpose of preparing maps of the rainfall of counties, or similar small areas, the quarter-inch scale is the most convenient, the hill-shading in the new edition being very effective; and in a few instances the half-inch maps combining both hill-shading and contours can be utilised. Bartholomew's series of maps on the scale of half an inch to a mile is in some cases a better basis for rainfall work than the Ordnance Survey maps on the same scale, on account of the greater contrast presented between high and low land, and the absence of the too conspicuous colouring of woodlands which, from the present point of view, are distracting features on the Ordnance Survey coloured sheets.

In mapping the rainfall of the British Isles, it is convenient to have the whole country represented on one sheet with a great number of place-names by which to find the position of stations easily and exactly. For this purpose the 10-mile-to-an-inch Ordnance Survey map is too large, and I generally use a special edition of Bartholomew's Railway Map, on the scale of 19 miles to an inch, and measuring 34 ins. by 30 ins. It is printed in pale grey so that pen-work stands out clearly upon it, and

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there are two tints of shading distinguishing the land over 500 feet and over 1000 feet above sea-level respectively. For purposes of semi-diagrammatical representation it is sufficient to use a mere outline map, perhaps with a few rivers and names to guide the eye; but in such cases, for instance, as the rainfall maps published in the *Monthly Weather Report*, the isohyets are copied from the original plotting on detailed maps on a much larger scale. The map of rainfall expressed by means of isohyetal lines may be used either qualitatively, as representing the distribution of rain in a graphic form, or quantitatively, for the purpose of measuring the amount of rain falling on a given area. The former purpose will claim most of our attention this evening, although the latter is no less important.

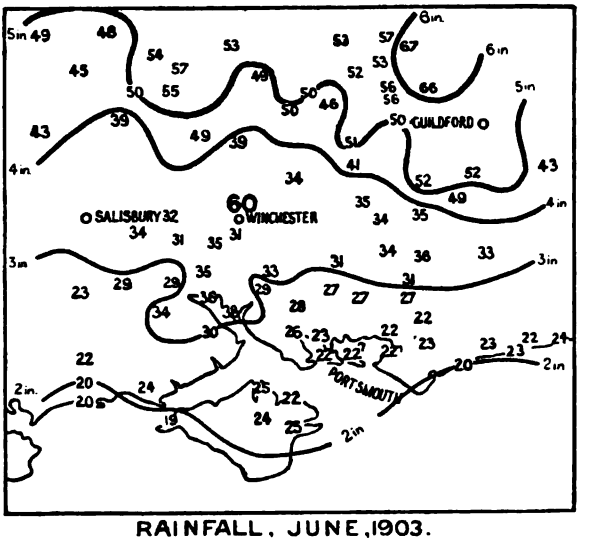


FIG. 1.—Map showing the Detection of an Erroneous Return.

The first use of maps in the routine of the collection of data in the office of *British Rainfall* is as a detective agency for the discovery of accidental errors. The monthly totals from about 700 stations are entered upon a map of the British Isles as they are received, and isohyetal lines are drawn for each inch, and sometimes, when the range of rainfall is small, for each half-inch. It is almost always found that the rainfall varies from point to point in a regular manner, though not always in the same way, and when one figure is observed much larger or much smaller than those surrounding it, a careful examination of the record almost invariably shows it to be in error. A neat example is shown in the annexed map (Fig. 1), which gives in tenths of an inch the rainfall for a month. The figure 60 north of Winchester was ultimately acknowledged by the observer to be a mistake for 36. When the same station shows a discordant figure month after month, the error is almost always traced to some imperfection of the rain gauge or some mistake in its exposure. Wilful errors on the part of observers are so very rare that I cannot say I have ever been able to satisfy myself as to one. Now and again, it is true, an

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individual anxious to prove the dryness of his neighbourhood may neglect small falls, now and again another may give undue importance to such small falls, but as a rule observers' errors are due to honest mistakes or simple carelessness. The commonest sources of systematic error are reading the gauge at some hour other than 9 a.m., or entering the result to the date of reading instead of to the previous day. It is obvious that erroneous returns are most easily detected in the crowded parts of the map.

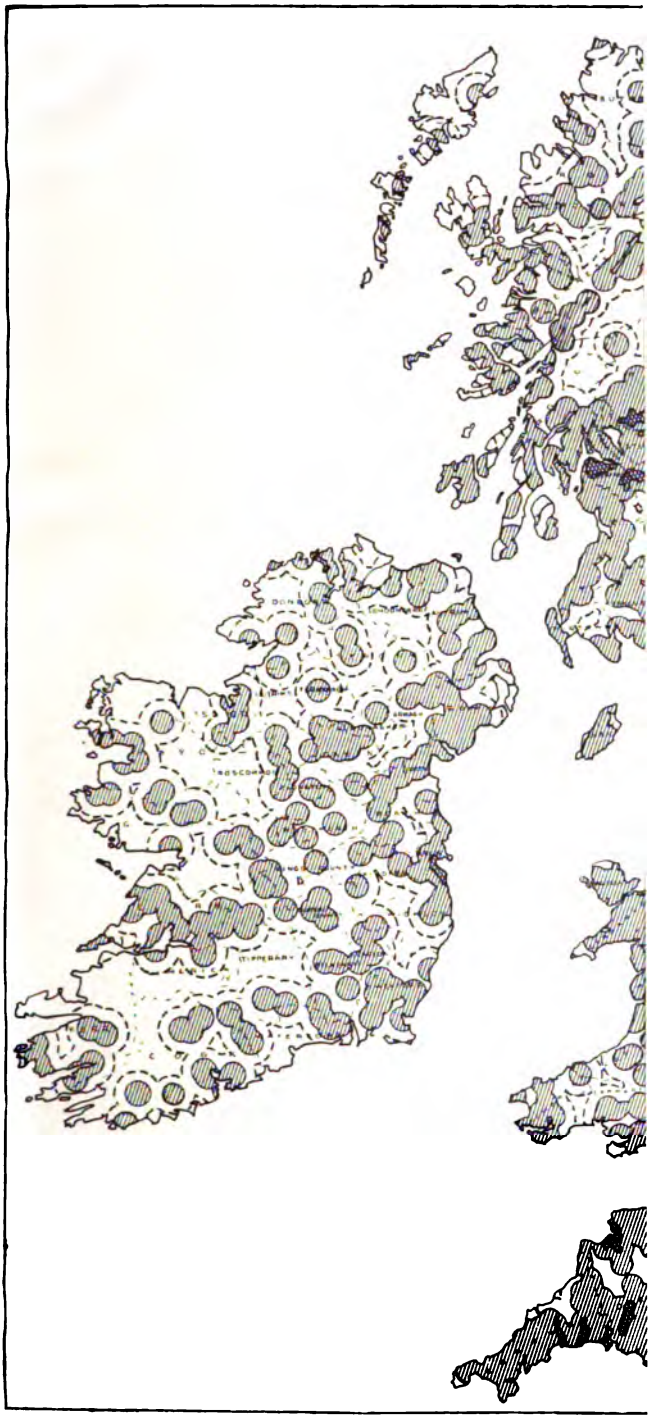
Annual returns are plotted in the same way, but the figures to place upon the map now amount to thousands instead of hundreds, and the isohyets, which can be defined with much greater detail, must be drawn at intervals of 5 or sometimes 10 inches; but the discordance of erroneous observations is none the less apparent, and errors due to instrumental deficiencies which were too small to show in the monthly figures may emerge into prominence on the annual map. The comparison of one record with a number of others in MS., or in printed form, is a slow and tedious process, whereas the comparison of the figures placed upon a map is simultaneous and almost automatic.

The detail with which the isohyetal lines can be drawn depends on the number of points for which data are available and on the uniformity of their distribution. Cases occur, however, where irregular distribution is a help, when, as rarely happens, observations are most numerous in places where the rainfall changes much in a short distance, and least numerous in places where there is little variation.

The rainfall map, after plotting all available figures and before drawing the isohyets, makes those parts of the country where observations are fewest very conspicuous by their blankness, and so directs attention to the districts where additional observers have to be sought. Attention may be called incidentally to a method of representing the density of population of rainfall observers, who number about 1 in 10,000 of the population of the British Isles, by shading distinctively the areas where there are more than twenty rain gauges in each 100 square miles, those in which there are more than one rain gauge in each 100 square miles, those areas more than 5 miles, and those more than 10 miles from the nearest rain gauge (see Plate 1).

On a large scale map it is impossible to draw isohyets across the blank spaces with any confidence as to minute accuracy, though the general run of the lines can usually be approximated to by following the prominent physical features of the country, or by preserving a general congruence with the curves for which there are data sufficient. It is difficult as yet to lay down rules, but experience brings facility in overcoming these difficulties, and two persons accustomed to draw such maps usually arrive at the same results. There is particular gratification when, as has more than once occurred, returns from the centre of a blank area have come in after the map was drawn, and the observed value fits so well that it does not require a line to be deviated for its accommodation. Ultimately it may be found possible to formulate certain relations of distance, altitude, and configuration, which will enable us to deduce with certainty the distribution of rain in an area without observers, provided it is surrounded, though perhaps at a considerable distance, by rainfall stations.

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Quart. Journ. Roy. Met. Soc., vol. **34**, Pl. 1.

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The study of daily rainfall by making isohyetal maps is beset by a few special difficulties. The record used must be "perfect," that is to say, it must represent the result of examining the rain gauge at 9 a.m. on every day in the year whether rain has fallen or not, and the amounts must be entered to the date of the commencement of the 24

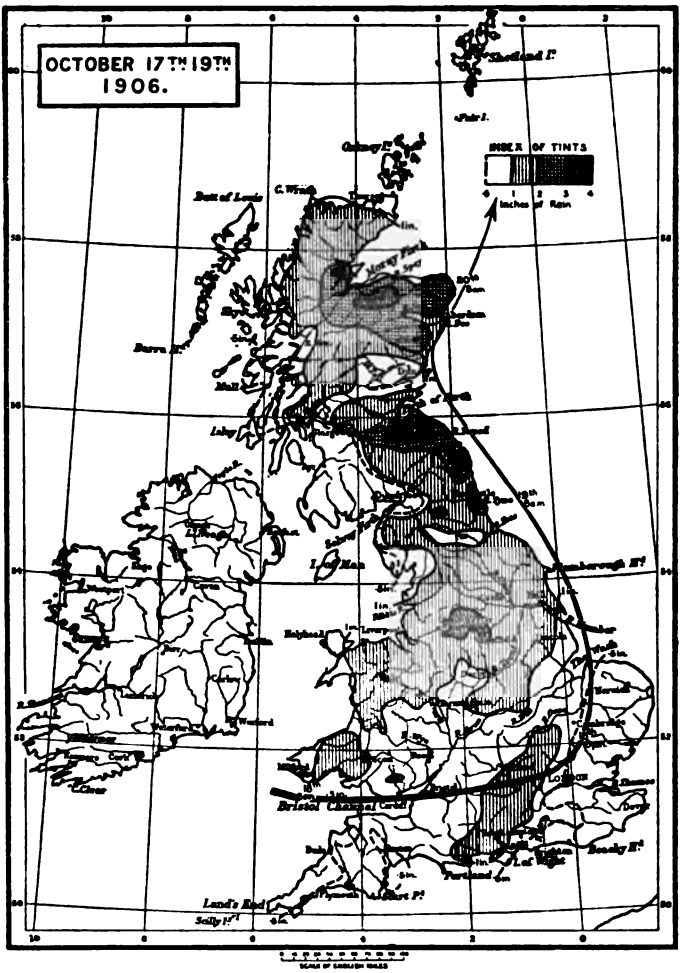


FIG. 2.—Map of Heavy Rain.

hours the reading for which is recorded. Although every year shows improvement in the directions of accuracy and uniformity, it is still very difficult to draw a rainfall map of a large area for a day of light rainfall. The rainfall of two days is apt to be confused, or a small fall may be omitted on its proper day and swell the amount on some other date. In the case of a very wet day, say the wettest day of the year, for any small area, mapping becomes quite easy, and one may have

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complete confidence in the result. Falls of more than one inch of rain as a rule stand out conspicuously, and serve as index marks by which the trick of entering the readings to the "wrong day" may in most cases be readily detected.

For the last seven years maps of the rainfall on the wettest days

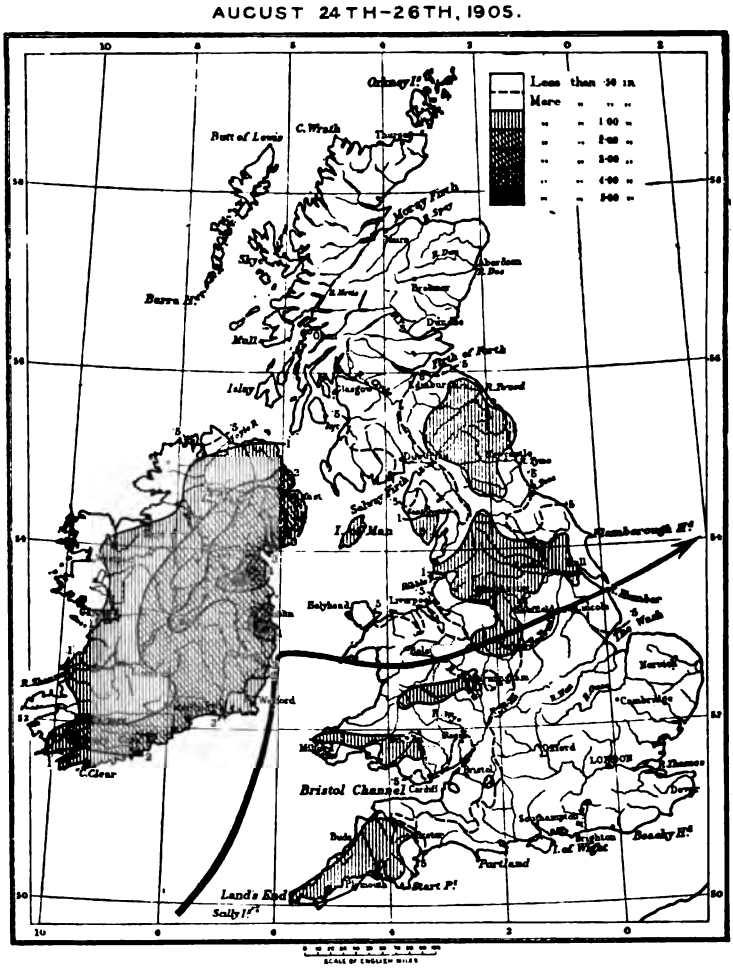


FIG. 3.—Map of Heavy Rain.

have appeared in each issue of *British Rainfall*, and the study of these maps reveals some interesting facts. A heavy rainfall, it is seen, rarely prevails over a wide area, and it is sometimes very restricted indeed. Two types of rain distribution on wet days may be distinguished as (*a*) the small, narrow, and often radiating splashes of thunderstorm rains, and (*b*) the wide uniform smears of the rain accompanying cyclonic disturbances. Both varieties of heavy rain have this in common, that they

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fall impartially on high ground or low ground, their incidence and outline showing no apparent relation to the configuration of the country. It seems, on studying the maps of a large number of wet days, that the causes determining the fall of the rain on these occasions are to be sought in the air alone, and that at a level so far above the surface that inequalities of ground, even amounting to several thousand feet, are without direct influence upon them. It is perhaps too soon to speak with certainty on this subject, as heavy falls of the two types on individual days have not yet been mapped in every part of the British Isles—nor very often in any part; such instances as are available point to the general conclusion stated.

The natural unit to adopt in mapping heavy precipitation is not the day, for heavy falls of the thunderstorm type are of such intensity that the full amount, even up to three or four inches, usually falls in from one to three hours only; whereas heavy falls of the cyclonic type are usually gentler, but more persistent in character, so that the precipitation may require many hours in which to accomplish itself, and may even extend without intermission over parts of three days. The remarkable cyclonic rain of June 13-15, 1903, in the lower valleys of the Thames and Lee lasted for close on 60 hours. Thus in mapping thunderstorm rains the day is so long a time that there is a risk of including more than one storm, and so losing the characteristic outline and variation of intensity of the single splash. In the case of cyclonic rains, on the other hand, the day is often too short, and only takes account of a portion of the shower. There are many cases where a day's rain is entirely due to one thunderstorm, and many where the whole of a cyclonic storm is included within a day; but it more often happens that the onward movement of the cyclonic system requires account to be taken of the fall of two or three days.

Put broadly, we may say that heavy rains of both types are due to purely meteorological causes, and their elucidation must be sought in the configuration of the atmosphere as revealed by changes of pressure. Thunderstorm rains as a rule may be associated with squalls, cyclonic rains with storms, and the distribution of the rain, as has already been pointed out,[1] bears a definite relation to the track of the depression producing it.

As there are few really good records from self-recording rain gauges available, it is not possible to trace the travel of the rain-splash across the country, or to take account of its variation in size and form. In the case of the storm of November 11 and 12, 1901, when the cyclone track crossed Ireland and England from west to east, the smear of the rain splash of the 11th lay on the left of the track, and embraced nearly the whole of Ireland, the west and north of Wales, and ended with a nearly semicircular front in Yorkshire; while the smear of the rain-splash of the 12th began in the north-west of Ireland and extended to the east coast of Great Britain from Berwickshire to Lincolnshire. Had it been possible to ascertain the rainfall for each 12 hours the smear could, of course, be dissected into four overlapping splashes, the fronts of which

[1] "On the Unsymmetrical Distribution of Rainfall about the Path of a Barometric Depression." *Report*, British Association, 1904, p. 480, and *Symons's Meteorological Magazine*, 39 (1904), pp. 161-165.

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would indicate to some extent the relation of the rain area to the advancing cyclone. When the splashes of the two days are united to give one smear, we find a broad band of rainfall exceeding an inch



FIG. 4.—Isochronic Map of Christmas Snowstorm, 1906.

stretching with a breadth of 200 miles across the country from coast to coast on the left of the track of the depression. There is no reason to suppose that such precipitation is less heavy over the sea than over the land.

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The commencement of a snowstorm is more easily noted, and more likely to attract attention than that of a shower of rain, and in the case of the Christmas snowstorm of 1906 it was possible to prepare maps

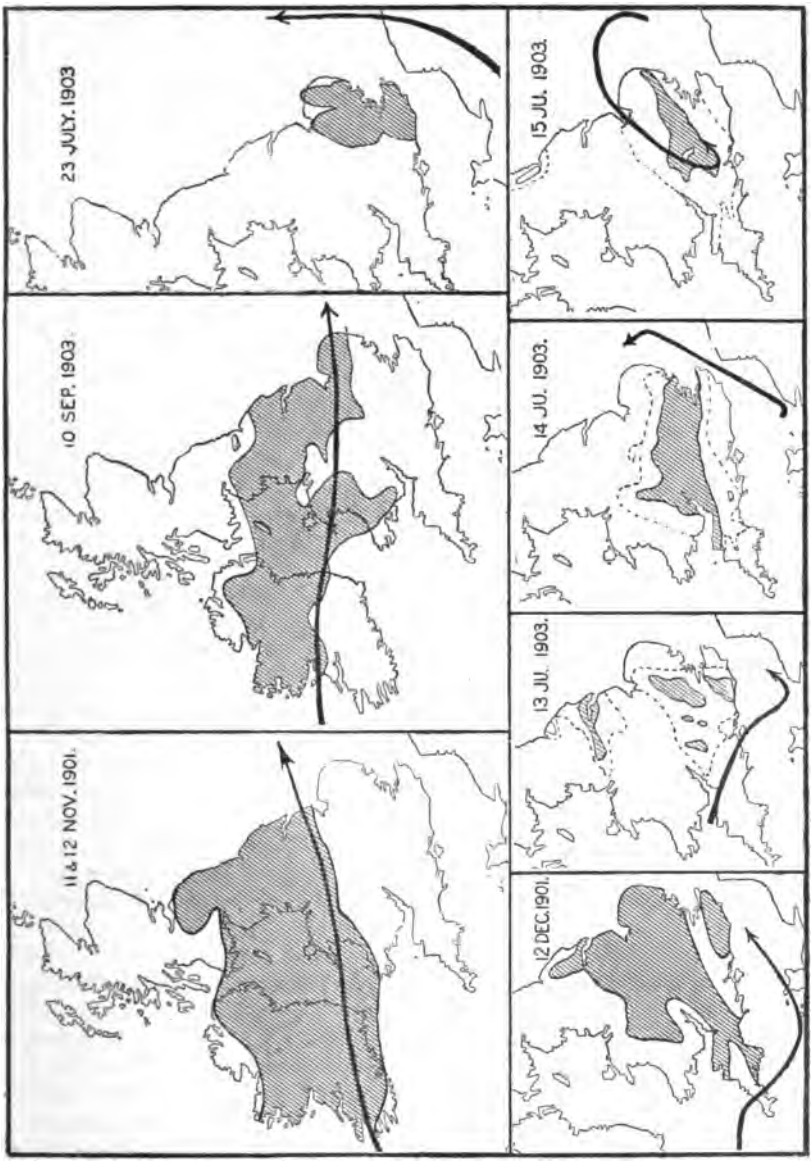


FIG. 5.—Specimens of Rain-Splashes.

showing isochronic lines as well as lines of equal depth of snow; and it is instructive to note that along the axis of greatest depth of snow the isochronic lines show a distinct bend forwards, indicating that the phase

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of the storm was earliest along this belt which lay parallel to the track of the depression and on its left (Fig. 4).

A third example of the combination of the rain-splashes of individual days into a continuous smear—this time in the case of a small and shallow depression pursuing a looped path curving to the left, so that the area of heaviest rain was always on the inner side of the loop—is afforded by the memorable storm of June 13-15, 1903, when rain fell continuously for about 60 hours (Fig. 5, last three maps). On the 13th, when the depression was passing from the Bristol Channel past the Isle of Wight towards the coast of France, no rain fell on the Welsh mountains or on Dartmoor, or in the Lake District, while more then one inch was deposited in five areas in the Thames Valley, the largest being the farthest east on the comparatively low ground of the valleys of the Lee and the Medway. A splash of more than an inch also occurred in the valleys of the Don and Humber, the southern and northern wet areas being separated by a broad belt of country where less than half an inch was recorded. On the 14th, while the depression was nearly stationary in the Channel for many hours, and afterwards moved north-eastwards through the Strait of Dover, and thence parallel to the coast of East Anglia, the Welsh mountains, Dartmoor, and the whole north of England had again less than half an inch of rain, while a broad belt with more than an inch stretched straight across England from the estuary of the Severn to that of the Thames. Within this area four splashes of more than two inches occurred in line from west to east—one on Exmoor, two in the Thames Valley, and the largest and heaviest on the flat plain of Essex. On the 15th, when the track of the depression doubled on itself, and struck across England from the Wash south-westward to near Southampton Water, the splash of over one inch of rain lay parallel to the track some distance to the south of it. This again lay mainly in the Thames Valley, this time covering part of the Cotteswolds, the Marlborough Downs, and the Chilterns, but continuing in a narrower band through the eastern plain in Essex and Suffolk.

When the total rainfall of the three days is plotted on a map the smear of the rain, which in this case is doubled on itself, like the smear of a paint-brush worked to and fro, is seen to be very extensive for the area over 1 inch. A small area on Exmoor, and a very large area stretching east and west from the Bristol Channel to the coast of Suffolk and the Thames estuary, has a fall exceeding 2 inches; and, symmetrically arranged within this, a similar area reaching from Marlborough to the coast of Essex with more than 3 inches. Within the 3-inch belt four areas with more than 4 inches of rain are arranged in line from west to east. The high land of the Cotteswolds, Salisbury Plain, and the North Downs, come just within the area of more than 2 inches of rainfall. The area over 3 inches covers the Chiltern Hills, but shows a higher rainfall over the Oxford and the Essex plains, and the 4-inch patches are larger and heavier towards the east in the centre of the sweep of the depression's path. The relation of the amount of rainfall is thus with the atmospheric, and not the terrestrial, configuration.

The linear arrangement of rain-splashes in the map of a wet day suggests that there is some periodic increase and decrease of the intensity of rainfall in an advancing shower which is not generalised away by the consideration of 24 hours instead of the shower unit. One of the best

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examples of this was presented on July 26, 1904, in a thunderstorm rain, a type more apt to show this characteristic than the cyclonic (Fig. 6).

These instances fairly illustrate the independence of surface relief shown in the intensity or distribution of great showers, and the close relation they bear to the passing minima of pressure.

Proceeding now to maps of the rainfall of a longer period such as a month, the total amount of which is often less, though usually more, than that of one of the wettest days, we find a curious divergence in character. Some months present a close resemblance in type to a wet day, or to a long cyclonic rain, the rain showing little regard to



FIG. 6.—Linear Arrangement of Rain-Splashes.

configuration of the ground; and this is not surprising, since it is no uncommon occurrence in summer for more than half of the rainfall of a month to fall in a thunderstorm on a single afternoon, or for this to occur at any time in a prolonged cyclonic rain. Thus the three days, June 13-15, determine the character of the rainfall map of June 1903 (Fig. 7).

On account of the great variation in the rainfall of a month, from nothing up to 6 or 10 or more inches, a very long period is necessary before average values can be secured which would not be considerably affected by the addition of a month of minimum or maximum rainfall. Thus if the average rainfall of one month for 30 years is 4·00 ins., the average for 31 years would be raised to 4·19 ins. if the rainfall of that month in the thirty-first year were 10·00 ins., and reduced to 3·87 ins.

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if the rainfall were nothing, the difference to be expected being a range of 8 per cent. If the period were increased to 50 years the corresponding range would be only 5 per cent, and there are no records long enough



FIG. 7.—Map of Abnormal Monthly Rainfall.

to reduce the range appreciably below this figure. Hence it is practically impossible to compile an average map of monthly rainfall from which the disturbing influence of occasional very wet days would be eliminated.

As a rule, however, monthly maps of rainfall closely resemble each other in their general character, and if we disregard those amongst them

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which bear the impress of one particularly wet day or spell, we cannot but be struck by the close relation which the amount of rainfall bears to the configuration of the land. The monthly rainfall map, in fact, is usually



FIG. 8.—Rainfall Map of Wettest Year.

a blurred impression of the hypsographical map; the region where high land prevails is that where high rainfall prevails, and the region of low land is the region of low rainfall, whether it be inland, or on the east coast, or on the west coast, while there is reason to believe that the general rainfall over the sea is less than that over the land.

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The total rainfall of a year, when plotted, rarely shows much influence of individual wet spells, and a collection of annual rainfall maps does not present the diversity of feature found in a collection of monthly maps. The general resemblances are so great, and the diversities so unimportant that, speaking broadly, the run of the isohyetal lines is similar for the wettest or the driest year on record, for 1872 or 1887: though the general rainfall for the whole of the British Isles was 53·0 ins. in the former case, and only 30·5 ins. in the latter. An average map was prepared in 1903[1] for the period 1870-99, 30 years, based upon a selected list of 380 stations for which 30 continuous years of observations were available, and raised to 1050, by including somewhat shorter records reduced by calculation to the equivalent amounts for 30 years. The general rainfall of the British Isles deduced from this average map was 39·5 ins. The stations were as nearly equidistant as possible, and the isohyetal lines were drawn with reference to the figures solely on a map devoid of natural features, either land-relief or rivers. The result was to confirm a fact that had long been accepted as true, viz., that the rainfall was greatest in the neighbourhood of high land or diversified country, and least on low or level ground. In fact, the map of average rainfall presented a closer resemblance to the map of configuration than did any of the rainfall maps of individual years, and it might be said to be a less blurred impression than they. The isohyets were similar in their direction to the isohyets of individual years, though no year is a precise duplication of any other either as regards relative distribution or actual amount of rain, and in 1903, at least, the influence of an unprecedentedly wet period in a dry region is distinctly shown.

Much more detailed pieces of mapping have since been done of counties,[2] and groups of counties, and in every case the distribution of average rainfall for a period of 35 years has been found to show a detailed relation to the configuration of the land. The best instance of this is to be found in the map of Kent and Sussex, with portions of adjacent counties, where the influence of the hills and valleys of the south-east of England on the distribution of rainfall is beautifully shown. So close is the relation where observations are numerous, that it seems reasonable to cross bare places by following the lines of the configuration of the land. It must be remembered that in drawing a line through an irregular group of determining figures we have to be guided by probability, and that to rule a straight line between two points that are fairly fixed is in most cases to adopt the least probable route that could be imagined; the contour lines of level usually suggest the outline of the most probable route from point to point.

The present address is concerned with methods, not with results, but I can hardly touch on this part of the subject without pointing out that the side of a mass of high land which faces the prevailing wind shows a comparatively gentle and fairly uniform increase of rainfall with elevation, that the increase continues beyond the summit for a short distance, and is then succeeded by a much more rapid decrease of rainfall as the height diminishes. Such a relationship is to be expected only when the hills

[1] *Minutes of Proceedings, Inst. C.E.*, vol. **155** (1903-4), Part I.

[2] See the *Water Supply Memoirs* of the Geological Survey for the counties of Lincoln, Suffolk, York (East Riding), Bedford, Northampton, Kent, Sussex and Oxford.

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are of moderate height; if it were a case of lofty mountains rising above the snow-line, the increase of precipitation would cease before the summit was reached. Slope probably plays an important part in determining how far beyond the crest the maximum precipitation occurs, and there is an immense amount of work to be done before the details of the relationship can be fully stated. While the relations that have been ascertained can be legitimately used as a guide in drawing isohyetal lines in desolate places, and may justify doubt and inquiry in instances of gross discrepancy, I do not think it is permissible for merely theoretical considerations to over-ride the evidence of a direct observation with which no fault can be found.

The average rainfall map may be taken as showing the effect of the interaction of the permanent configuration with the prevailing or average wind; but in individual years the wind may vary considerably both as regards mean direction and mean force, and the effect of these variations remain for future study.

Experience shows that when maps of individual years are constructed to show, not actual rainfall in inches, but difference from the average in percentages, certain tracts of country may be shown to be persistently above or below the average for several years at a time. The fact that the outlines of these tracts are often parallel to the usual paths of depressions suggests the idea that in certain years, perhaps in several successive years, the paths followed by the depressions bringing the heavy rain that falls irrespective of the form of the ground may be diverted to the north or the south of their usual course, or that more cyclones may follow one or another of the recognised tracks, and so create differences in the distribution of rainfall quite independent of such changes as many occur in its quantity. At present we are not in a position to investigate this part of the subject, because the average rainfall maps now in existence are not detailed enough; but when the series of complete annual maps of rainfall now being compiled at the expense of a rainfall observer is completed, it should be possible to combine them in some way so as to yield a map of average rainfall for more than forty years, the value of which ought to be very great.

In any individual year the total rainfall shows an unmistakable relation to configuration. The prevailing wind over the country is more or less South-westerly; but the fact that the wettest portion of the rain-splash in any squall or cyclone which produces a very wet day lies wholly to the left of the track, shows that in storms pursuing the more usual tracks from a westerly to an easterly point the maximum precipitation takes place with an Easterly and not with a Westerly wind. We have seen, however, that the splashes, or, to be more precise, the smears, of heavy rain show no apparent relation with configuration, but fall equally on highland and lowland, hill-brow or valley floor. It would, therefore, appear to be necessarily true that the elimination of all such heavy meteorological rains would leave the remaining geographical rains much more intimately associated with the configuration than is the total rainfall of any year.

The attempt to differentiate between the two classes of rainfall is extremely difficult because of the enormous labour of analysing a sufficiently large number of perfect daily records to yield a map detailed enough for the necessary comparison. An attempt has, however, been made

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to separate the rainfall into the two types. For this purpose England and Wales were alone considered, and 300 stations with perfect daily records were selected to give as uniform a distribution over the surface as possible.

One map was prepared from the 300 points showing the total annual rainfall for 1906, a year which on the whole closely approached the average. The question, then, was to decide what rainfalls to sift out as probably of meteorological origin, and it seemed hopeless to attempt to sort out all days of cyclonic storms and squalls and deal with the stations within the storm area on each occasion. At first the maximum fall (*i.e.* the rainfall for the wettest day of the year) was taken out, and the change on this occasion was so slight that all other days were taken on which the rainfall reached or exceeded 4·5 per cent of the annual total, that being the average percentage of the maximum fall. A map was constructed from the 300 points showing the total fall, less the maximum fall, and all falls exceeding 4·5 per cent of the average, and this was compared with the map of total annual rainfall. It was found that the 300 points were not sufficient to allow the isohyets to be drawn with sufficient precision to allow of a close comparison, but looking at them in their broad features only, and disregarding details as far as possible, one could see a perfectly clear smoothing and mellowing of the outlines. The map of total rainfall, minus heavy falls, was more like the average map than was the map of total rainfall from which it was derived, the differences being most easily seen in the Eastern Division of the country, where the effect of the low hill ranges on rainfall became more prominent. In the Western Division there was comparatively little change, the isohyets in both maps showing an equally close correspondence to the configuration.

A further step was then taken, and all daily falls which individually exceeded 1 per cent of the annual total rainfall at the station in question were excluded. The map expressing the distribution of this doubly reduced rainfall was still in close accord with the configuration in the Western Division, but in the Eastern Division the isohyets were broken up and confused, suggesting that the process had been carried too far.

Having done so much I thought that it would be worth while to attempt a little more by applying the same process to the records of a year which was widely different from the average, and 1903 was selected for this purpose, as it was one of the four wettest years of the last hundred, and it contained a number of notable heavy falls. The same limits of reduction were adopted. This time the withdrawal of the day of maximum fall and all days with more than 4·5 per cent of the average fall produced very little change, as the total rainfall was so unusual that even a large daily fall formed but a low percentage of it. The second reduction by withdrawing all days with more than 1 per cent of the annual rainfall produced a considerable accentuation of the relation of rainfall to the surface relief of the Eastern Division of the country, and evidently came nearer to securing the elimination of the meteorological rains; but the result was not striking.

To complete the test of the method a very dry year, such as 1887, should have been treated in the same way; but time could not be found for doing this. The result of the attempts that have been made

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goes to show that the method is a promising one if a sufficient number of records can be secured to give definiteness in drawing the isohyets, and if one can ascertain the proper amounts to be deducted in order to weed out the meteorological rains and leave the configurational rains alone. An attempt may be made at some future time to apply the method to a smaller area on a larger scale. Meanwhile enough has been done to show that the elimination of the heavier falls of rain leaves the residual amount in closer harmony with the surface features of the land, and that even without modification the rainfall of every year corresponds so closely with the configuration of the country as to prove that a relationship of cause and effect exists between them, and this relationship is undoubtedly what is termed in geography a control of rainfall distribution by the land.

For many practical purposes it is important to ascertain the total

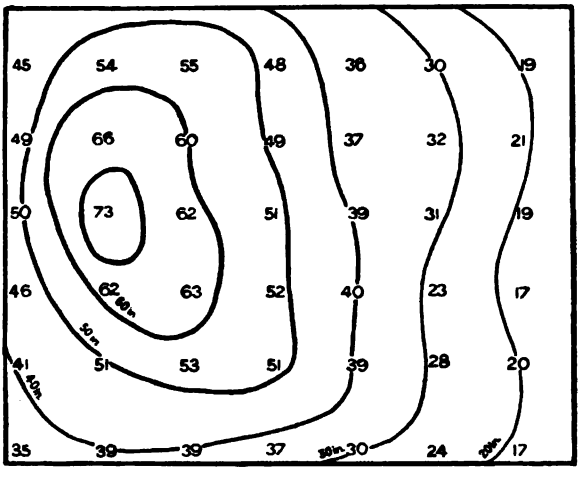


FIG. 9.—Isohyets for Regular Distribution of Stations.

volume of water which falls as rain on particular areas, and when the area is large, a river basin for example, the only really satisfactory way is by the use of a rainfall map. The problem of finding the general rainfall of an area on which there are numerous records appears to most people at first sight to be solved by the simple process of taking the mean of all the records which exist. A little thought, however, is sufficient to show that it is only in very rare circumstances that this is the best course to follow. It is only when the stations are uniformly distributed over the whole area, and sufficiently numerous to represent all the different intensities of rainfall proportionally, that a mean of all the figures can give the true general rainfall. When there is little difference between the rainfall in different parts of the area a comparatively small number of stations will suffice to give a representative mean value; but the greater the diversity is, the greater is the number of stations required for the purpose. When, as in this country, the rainfall records are not taken at selected points chosen as to position and number, but here and there for the most part at the hazard

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of the grouping of the homes of the one ten-thousandth of the population interested enough to become observers, stations are not sprinkled uniformly over the surface, but clustered together in favoured residential districts and totally lacking in many large areas. The mean of such irregularly distributed stations can only represent the general rainfall by accident. Thus if in a county there are 30 rain gauges in a hilly district of 400 square miles, and 5 in a stretch of level fenland extending for 1000 square miles, the mean of the 35 records would give far too high a figure for the rainfall of the county. Even one phenomenally wet station may greatly disturb and misrepresent the rainfall of the county; for example, if the records of the three rain gauges at The Stye are included amongst 50 stations in Cumberland, the mean for the whole county would be raised several inches above the true general fall. It is difficult,—indeed, I have sometimes found it impossible,—to

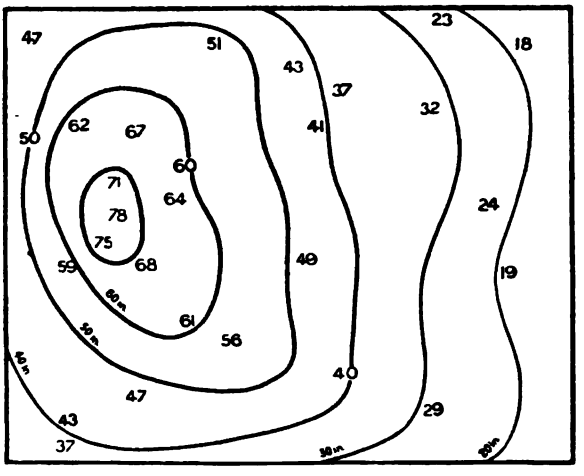


FIG. 10.—Isohyets for Irregular Distribution of Stations.

convince people who are intelligent in most matters, that by omitting half the records of rainfall one could in certain cases obtain from the mean of the rest a far closer approximation to the general rainfall than by taking the mean of all. Dealing with numerals alone in a tabular form they fail to see that space and grouping have to be considered as well as number, and that in taking an arithmetical mean as expressing the general value they are making the great and unwarranted assumption that the distribution of the stations is uniform and representative.

When all the data are placed upon a rainfall map the drawing of isohyetal lines involves some assumptions also, as we have seen; but these are of a smaller and more reasonable kind. From an isohyetal map the general rainfall can be obtained by various methods. One of these, and perhaps the most accurate, is to construct a number of sections along parallel lines at close intervals across the map, the co-ordinates being distance and depth of rain, then measuring the area of each section, adding all the areas together, and dividing by the total length of the sections to give the general rainfall.

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A simpler method is to measure the area between consecutive isohyetal lines upon the map, multiply the area by the general rainfall of the zone, add all the resulting figures together, and divide by the total area. For convenience I measure the areas in square miles to the third decimal place, and the rainfall in inches to the second decimal place, the resulting volume of rain being given in the conveniently large units of the square-mile inch which is equal to 14,480,000 gallons. The only serious risk of error in this method lies in estimating the general rainfall of the zones, and this is much less than might appear at first. Where the isohyets are numerous and equally spaced it is safe to take the general rainfall of the zone, between say 30 and 35 inches, as the mean of the two limiting values, *i.e.* at 32·5 inches. Where, however, the isohyets are becoming successively nearer, or successively farther apart, from the lower to the higher value, it is necessary to allow in the former a lower, and in the latter a higher value than the mean. In practice the actual figures usually serve to show whether the mean value has to be diminished or augmented, and by what amount; and even if this rectification is not made the error in most instances is not a great one. All calculations of the volume of rainfall are subject to the limits of accuracy of the individual observations, and it is taking a very favourable view to assign one-tenth of an inch as the smallest difference which has any significance in the figure for annual rainfall.

It happens that rainfall is not only the most difficult of all the meteorological distributions to map accurately, it is also that one which is of the greatest practical importance; for by rain the rivers are fed, and the rivers both water and drain the land. The value to agriculture of a knowledge of rainfall and its seasonal incidence is great, but not so great as the value to other interests. Every year makes clearer the vast national importance of accurate knowledge of the rainfall of a country, for the problem of the rivers is becoming acute. The growing populations of the great towns are tapping the upper streams and diverting the water from its natural channels, and at the same time they are polluting the lower courses with the waste of the factories and the streets. Toll is taken all along the banks of industrial streams of water for raising steam and carrying on the multitudinous processes of manufacture. There is sometimes anxiety as to whether the waterways can be kept sufficiently supplied to float the water-borne traffic, or to fight the silting action of the tides in the estuaries, and there is growing alarm as to the possibility of fish traversing the depleted and polluted streams to reach their spawning beds.

Of recent years the value of the water-power which may be generated in the lonely and lofty places amongst the western heights of Great Britain, where the rainfall is large and unfailing, has been recognised; and chemical works for the production in electric furnaces of what a few years ago were rare substances are becoming familiar features in Wales and the Highlands. In Ireland, too, the rainfall is an unrecognised source of wealth which as yet has not been drawn upon to any appreciable extent. The increasing strenuousness of the struggle for the possession of large water-supplies is producing in England, and especially in Wales, a great amount of local jealousy and strife, for the boundaries of parishes and counties coincide but rarely with water-partings, and the argument

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has been brought forward again and again that the rainfall of one county should not be diverted for the use of the inhabitants of another. The feeling is intensified when the boundary to be crossed is that of a historical division of national importance, like the boundary between England and Wales; but I think that the map-study of rainfall can do something to suggest the lines on which such disputes should be settled. A great statesman once recommended the study of large-scale maps for the solution of political difficulties, and no doubt matters of detail are often important enough to require such aid; but in order to grasp the true bearings of large subjects in their entirety we must use a small-scale map, or we fail to get a comprehensive view. We have seen that although the exceptional deluges of a thunderstorm or a great depression fall with equal and impartial heaviness on the hills of the west or the flat plains of the east, the common every-day rains are precipitated on the high lands and in the mountain valleys, which cross the track of the prevailing wind, in much greater abundance than on level and low stretches of country. Most of the rain is borne to our islands from the Atlantic, and, when it comes torrentially, it is a thing of the air alone and no boundary checks it; but the largest annual falls come down on and near the watersheds, because there the land produces its maximum influence as a rain-compeller. In our youth we were taught that mountains attract rain, but that is rather a misuse of words unless we stretch the word "attract" so far that we could speak of a body of bandits attracting plunder. If the high ground of Wales, the Lake District, and the Pennines were not there to obstruct and plunder the Westerly winds the lower heights of eastern England would receive a much greater annual rainfall than they do.

From the high ground the rivers seek the plains, carrying off the excess of rainfall into the less liberally watered districts. The Dee, the Severn, the Wye, and the Usk restore to England part of the rains which the Welsh mountains have abstracted as the air passed over them. The high rainfall of the whole Pennine district, sometimes by circuitous routes across the comparatively dry plains of the east, swells the volume of fresh water that pours into the Humber. The Thames itself receives the comparatively high rains of the Cotteswolds, the Chilterns, and the Downs, and forwards the water slowly through less and less rainy districts until it reaches the sea in the driest part of England. I think that a far stronger argument can be drawn from this consideration of physical geography in favour of supplying the great towns of the east from the large precipitation of the west, than can be drawn in the opposite sense from the artificial divisions of political geography. It seems to me that care for the water-supply of the country, coming as it does from the air that knows no bounds across the land, is by no means a parochial, but in the fullest sense a national matter, and should be dealt with in the interests of the nation as a whole—the units of subdivision when such are required being the natural units of river basins.

This Society owes something to the nation in giving expression to the possible practical applications of the science we pursue, and I am sure that if the public were once thoroughly aroused to the wide importance of our studies as they bear on every-day life, the general proceedings of the Society would be followed with a keener interest and the number of Fellows would greatly increase.

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FORMATION OF SNOW ROLLERS.

By CHARLES BROWETT.

(Communicated by the Director of the Meteorological Office.)

[Read February 19, 1908.]

At Ryton-on-Dunsmore, near Coventry, on the afternoon and evening of January 29, 1907, there were several storms of fine snow, which amounted to a depth of about 1½ in. The snow fell very evenly and without drifting.

The next morning at 8 a.m. I noticed that the snow on the lawn to the east of the house was heaped up as though some one had run with a spade in front of him. On going out I found myself face to face with a very curious phenomenon. The snow was cleared away to the bare grass (except for slight bars of snow across) in tadpole-like markings, whose tails all pointed to the direction from whence the wind had been blowing all night, viz. North-north-west, and at whose heads was heaped up the snow that had been on the bared grass, all neatly turned over in a roll. On looking about on the other lawns I found only a few of these markings, and on the field to the north none at all; but on the drive and grass in front of the north side of the house I found markings in the opposite direction, but with little snow actually curled up, although the grass was bared in the vertebræ-like spots before mentioned. It was quite evident that these were caused by the deflection from the side of the house of whatever had caused the similar markings on the other side.

On driving into Coventry (4 miles) I noticed in many fields similar markings to the first mentioned; but the field that had most in was one sloping slightly from the north-west to the river Sowe. But oddly enough none were on the other side of the river, where the ground rose facing the wind. On inquiry I found several odd ones had been formed on lawns and fields to the north of Coventry. In every case the snow was as clean cut as with a knife. The main sheet of snow was not drifted in any way.

The following are the exact details as far as they could be obtained:—

Greatest length of any one marking 30 ft., average 20 ft., smallest about 6 ft. Width of grass cleared at the start, which was gradual, not less than 3 ins. to from 12 to 17 ins. at the widest part. Wind North-north-west. Force gusty up to about 25 miles per hour. The thermograph 5 ft. above ground recorded between 32° and 34° during the night. The surface of the snow was perfectly flat; no tufts of grass or any projections were in any way connected with the formations. Fine snow fell on and off all the previous afternoon. I do not think any snow fell after dark, but these markings were cut through all there was on the ground between 6 p.m. on January 29 and 6 a.m. on January 30, when it was fine. They were not made during any fall of snow. The edges were as sharp as if cut with a knife. The ridges across the figures were about a quarter of an inch deep, and were left about every 6 ins. I counted 13 in 7 ft. On either side of the heaped-up roll of snow the

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grass was always slightly cleared, as though the wind, being unable to push the snow farther, had divided and gone by on either side.

On the south side of the house many very strange forms had been cut on the lawns among the trees and shrubs; the most interesting and the best marked is shown in Fig 1. It was secured in the following way, as a photograph, even taken from the top of the house, was subject to perspective. I cut with a large knife the sharp edge of the snow down to the turf and put a number of pegs in this nick so that when the snow had gone very accurate particulars could be taken. To do this I marked out on the turf round it a square of 8 ft., its sides being north,

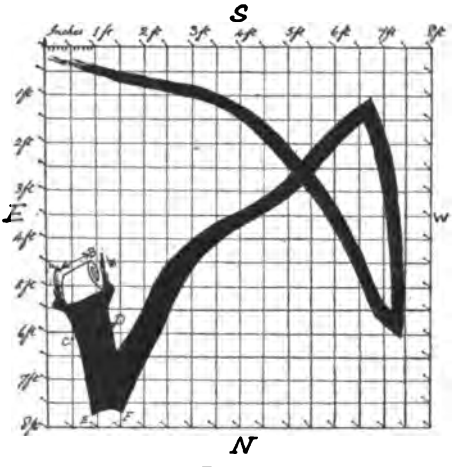


FIG. 1.

south, east, and west, and put a nail in every 6 ins. all round. Fine cotton was then passed backwards and forwards, and from its intersecting points the figure, as shown, was easily and accurately obtained. The distance across AB was always a good deal less than that at CD, where the snow at AB would have come from if simply rolled back. This showed a pushing-along action as well as a rolling one. If the roll could have been undone, it would not have reached more than a quarter of the distance along the bared grass. The figures on this side of the house were formed in all directions, the trees and shrubs causing an almost complete reversal of the direction of the main wind current. The curve at EF was very marked.

[The following extracts giving descriptions of similar phenomena observed elsewhere will throw further light upon the formation of "snow rollers."—EDITORS.]

From *Handy Book of Meteorology.* By ALEXANDER BUCHAN. Second Edition, 1868, pp. 202-3.

On the 5th March 1862, about 9 p.m., the Rev. Dr. Charles Clouston, Sandwick, Orkney, observed the snow which was then covering the ground to be rolled up by the wind into masses increasing in size as they moved before it, which were

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blown backwards and forwards in the eddy-wind of the house. The same phenomenon had occurred in February 1847, and was then described by him in the following terms: "On examination, the masses were all found to be cylindrical, like hollow fluted rollers, or ladies' swan-down muffs, of which the smaller ones reminded me, from their lightness and purity, but most of them were of much greater dimensions and weight than any lady would choose to carry, the largest measured being 3½ ft. long and 7 ft. in circumference. The weight, however, was not so great as might have been expected from the bulk; so loose was the texture, that one 3 ft. long and 6½ ft. in circumference was found, on being weighed, to be only 64 lbs.; the centre was not quite hollow, but in all there was a deep conical cavity at each end, and in many there was a small opening through which one could see, and by placing the head in this cavity in the bright sun, the concentric structure of the cylinder was quite apparent. They might occupy 400 acres, and I counted 133 cylinders in one acre. A combination of favourable circumstances is required for their formation —viz. a recent fall of loose snow-flakes in calm weather, as took place on the day previous; a temperature near the freezing point, so as to give adhesion to the snow, while it is not so warm as to thaw it; a good breeze of wind to spring up when the other circumstances are favourable to their formation."

From *Nature*, vol. 27, 1883, p. 483.

A Remarkable Phenomenon—Natural Snowballs.

Mr. Samuel Hart, Trinity College, Hartford, Conn., U.S.A., gives the following account of natural snowballs, which he furnished to the *Courant* newspaper, February 22, 1883:—

On Tuesday evening a light but damp snow fell upon the crust that had formed over the snow of Sunday's storm; and the South wind, which arose at a later hour, produced an unusual phenomenon. Wednesday morning the college campus, the park, and vacant lots everywhere hereabouts were seen to be strewn with natural snowballs, some of them resembling spheres with diameters of from 1 to 9 ins. or more, and others looking very much like rolls of light cotton batting, having a cylindrical shape, but in nearly every case with a conical depression at each end reaching nearly or quite to the middle. It was easy to see how the balls had been formed, as it is easy to see how boys roll up snow for their forts. The wind had in each case started a small pellet of moist snow, and it had rolled along until it grew so large that the wind could move it no farther. The ball not only increased in diameter as it rolled, but also grew gradually in length as a little more of the snow stuck to it on each side, as thus the snow was formed in the peculiar way described—that of a cylinder with a hollow at each end, as if a long isosceles triangle were rolled up beginning at its vertex. The largest of the cylinders measured on the college campus had a diameter of 12 ins. and a length of 18 ins.; while others in the fields in the neighbourhood seemed much larger. The path of the balls could in many cases be readily traced for a distance of 25 or 30 ft. The snow, it should be added, was not at all closely packed, but lay together very lightly and yielded to the slightest touch, so that it was impossible to move a ball without breaking it.

Observers in other parts of the city report that some balls were seen of the size of a barrel which left tracks behind them for more than 60 ft. From East Hartford it is reported that they studded the fields thickly, especially in places where the wind had a long range, and were of every size to that of a half-bushel or larger. Similar balls were seen yesterday morning in many places from the Sound north to Massachusetts. All along the line of the Valley Railroad they

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appeared on every rod of ground, and at some places they had left tracks showing that the wind had blown them in every direction, even in some cases uphill.

This interesting phenomenon, though quite unusual, has been noticed before in different places in this country and elsewhere, the most striking instance being one which was observed in New Jersey in 1808; this was in the daytime, when the whole process could be watched. On this occasion some of the masses of snow which were rolled up by the wind attained a diameter of 3 ft. They appear to have been seen over an area of only some four hundred acres, whereas the snowballs yesterday were spread thickly over many square miles.

From *Nature*, vol. 27, 1883, p. 507.

Snow Rollers.

The phenomenon described in *Nature*, vol. 27, p. 483, under the title of "Natural Snowballs," is known to British meteorologists under that of snow rollers, and as the latter agrees more closely with the phenomenon, I venture to plead for its adoption.

I believe that the first person who carefully examined their formation was that excellent and venerable observer, the Rev. Dr. Clouston of Sandwick Manse, Orkney, and I am under the impression that he published a description of their formation in an early number of the *Philosophical Magazine*. He has observed them on the lawn at Sandwick more than once, and has always noticed the hollowness at the ends; in fact, he described them to me as resembling ladies' white muffs.

I remember only one instance of their being reported in England, namely in the following letter from the late Admiral Sir F. W. Grey, which appeared in the *Meteorological Magazine* for May 1876. G. J. Symons.

62 Camden Square, N.W.

Sir—The snowstorm of Thursday night [April 13, 1876] was marked by one circumstance which I have never witnessed before, though it may not be uncommon. It was this:—

On Friday morning I observed that for a considerable distance, and following a regular line, the lawn, to leeward of the house, was strewed with masses of snow-like boulders, varying from the size of a snowball to a cubic foot at least, and as the snow melted, a track either straight or curved led up to the large ones, following apparently the direction of the wind. I had observed before dusk that the eddies of the wind and the swirls of snow were very marked, and I have since heard from a friend, who observed the same thing, that he saw the snow rolled along by the wind and forming masses such as I have described.

As I have said, I know not whether this has been observed in other cases, and perhaps it may interest you to have this account of it.—Yours faithfully,

F. Wm. Grey.

Lynwood, Sunningdale, Staines, *April* 16 [1876].

From *Symons's Monthly Meteorological Magazine*, vol. 20, 1885, p. 7.

Snow Rollers

Sir—On the 13th inst. a large number of "snow rollers" were formed here, and as I see from a letter in *Nature*, vol. 27, p. 507, that the

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phenomenon has not often been noticed in England, you may think the circumstance worth recording. I first noticed a few on the 12th, the snow being about 0·5 in. deep and a strong North wind blowing; more snow fell in the night and next morning, to a depth of more than 3 ins., and on going out in the afternoon I found all the open fields strewn with a number of rollers, varying in size from that of a hen's egg to cylinders about 9 ins. in diameter, and about the same length. I did not see any in course of formation, but there were tracks in the snow leading up to them on the windward side. The snow was rather moist, temperature being about freezing point, and lay light, 3 ins. of snow yielding about 0·11 in. of water at 9 a.m. A few of the larger ones were left next day, but the greater part had been blown away.

H. MELLISH.

HODSOCK PRIORY, WORKSOP, *January* 15, 1885.

From the *U.S. Monthly Weather Review*, 1906, vol. 34, pp. 325-326.

SNOW ROLLERS. By WILSON A. BENTLEY, Jericho, Vt.

During the night of January 18, 1906, there occurred at and in the vicinity of Jericho, Vt., the very interesting and somewhat rare phenomenon of the formation by wind action of vast numbers of snowballs, or snow "rolls" or "rollers." A brief account of them, and of the weather conditions that prevailed before and while they were being formed, may possibly be of interest to the readers of the *Weather Review*.

About five inches of very light, fluffy snow fell during the twenty-four hours immediately preceding the phenomenon. During this time the temperature ranged from 14° to 22° F. But during the night of the 18th, when the snow rolls were formed, the temperature slowly rose from 24° to 34°, and the lower wind shifted from Westerly to Southerly points, and blew at times in a very strong but intermittent and peculiar gust-like manner. The snow rolls were formed during the latter part of the night, after the rise to 34° was accomplished. This rise in temperature operated to cause a slight superficial melting of the upper layers of the snow, and to make it slightly damp, so that the individual snow crystals tended to cling to one another.

So far as the writer was able to observe, and to learn from others in adjoining towns, the phenomenon occurred only over a quite limited and narrow strip of foot-hill country perhaps one mile wide, lying alongside and parallel to, but at a little distance from, the western side of the Green Mountains. The winds that produced the phenomenon blew across the valleys and foot-hills rather than parallel to their greater length. The topography of the region in question is such as to cause the winds that reach the valleys, or at least some of them, to flow or pour downward into them in descending order from foot-hills of considerable height.

In many cases the gusts of wind evidently had a strong descending motion, such as just described, for they actually scooped up considerable masses of the light, damp, fluffy snow and formed it into ridges or hollow snow arches, and rolled many of these up into snow rolls of various sizes.

The forms and structures of the snow rolls were such as to indicate that, at least in many cases, the wind that scooped up the fluffy snow masses into ridges or open arches got in behind such ridges and arches (which may be termed "cores") and blew them over upon themselves or upon the snow directly in front and to the leeward of them, thereby imparting both rotary and forward motions to the snow core ridges or arches, blowing and rolling them along in this manner for some distance. Fresh layers of damp surface

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snow collected upon them as they rolled along upon the surface of the snow, and operated rapidly to increase their size and specific gravity. Eventually the rolls became so large and heavy that the winds were unable to roll them farther and they came to rest. Variations in exposure to winds and surface topography operated to cause some rolls to be blown along much farther than were others, hence some became of much greater size and weight than others. The individual snow rolls varied in size one with another, from tiny rolls but a few inches in diameter, to huge ones 18 by 24 ins. in size. In most cases the diameters of the rolls were much less than were their lengths.

Perhaps the most interesting rolls thus scooped up and modelled by wind action were those whose "cores" were of an open, hollow character. Such



FIG. 2.—Snow Rollers at Jericho, Vt.

came into existence in the form of hollow snow arches, as previously described, and were so substantial, or were rolled along so gently by the winds, that their hollow cores were preserved intact, *i.e.* were not filled in as a result of collapse or of their rotary experiences.

Unfortunately the day following the formation of the snow rolls was a dark cloudy day, unfavourable for photographic work, hence our original photographs of the snow rolls failed to show them with sufficient plainness, and it became necessary to increase their sharpness by recopying so as to produce extreme contrast effects. This explains why the trees, etc., show up so very darkly in these photographic prints (Figs. 2 and 3).

The wind came from the right-hand side of these photographs. They show the paths of some of the rollers, and their beginnings on the right-hand side. The accumulation of snow occurring on the right-hand, or windward, side of each roller was, I am certain, not blown there from a distance by the wind, but is, in each case, a partly detached layer of snow, that adhered to,

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and was partly lifted up by the roll, while that was revolving, but that settled back to earth at a later time, owing to the continuation of the process of partial melting that was going on at a temperature of 34° to 36°. In case the roller had undergone another revolution such windward layer would doubtless have gone with it and been incorporated within the mass. Many of the rollers formed on a practically level surface, and some were actually rolled up a slight incline.



FIG. 3.—Snow Rollers at Jericho, Vt.

From the *U.S. Monthly Weather Review*, 1906, vol. 34, p. 326.

SNOW ROLLERS AT MOUNT PLEASANT, MICH. By Prof. R. D. CALKINS.

On the evening of January 17 [1906], the wind at Mount Pleasant, Mich., was North-east, and a light flaky snow was falling. During the night the wind backed through North and North-west to the South-west. In the morning we found that, at the north-west corner of the Normal School Building, snowballs or snow rolls to the number of fifty or seventy-five had been formed. They varied in size from 3 ins. in diameter to 12 ins. They were rolls of snow rather than snowballs, for most of them had square ends. They were spiral in structure when viewed from the end. Behind each roll was a path where the snow had been taken up, and the depth of snow removed from this path corresponded very closely to the thickness of the layers forming the roll. These paths became narrower as the corner of the building was approached, where they all disappeared. The rolls were very light, and would hardly hold together sufficiently to preserve their shape when lifted. Some boys from the country on the same morning reported similar balls 2 ft. in diameter. The wind had a long unobstructed sweep from the south-west. There were no tracks of children about

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the balls, and there can be no doubt that they were wind-formed. Can you give me any more information concerning the origin of such balls or rolls? Just why and how do they start?

Note.—The initial step in the formation of snow rolls seems not yet to have been observed. They appear generally to be formed at night-time, or in the very early morning, and the diagram by Professor Calkins suggests that they are formed by or among the eddies in the strong wind at the corner of a building or other obstacle.

We note that in the *Meteorologische Zeitschrift*, May 1895, p. 198, Prof. K. R. Koch, of Stuttgart, mentions three ways in which snow becomes hardened after it has fallen :—

1. A warm snowfall is followed by cold West winds that favour compression, the wind in descending gusts forcing or pressing it into a hard solid mass.

2. Hard surfaces are formed by melting and freezing, and become hard enough to support the mountain climbers in the Alps and Black Forest.

3. In March and April, in the mountains, before thawing weather begins, the insolation is powerful, and snow crystals exposed in the sunshine are evaporated and the vapour is actually recrystallised ; thus very large crystals are formed, and the layers of snow become quite solid ; it is not impossible that large nuclei may thus be formed.—C. A.

From the *U.S. Monthly Weather Review*, 1907, vol. 35, pp. 70-71.

Snow Rollers at Canton, N.Y. By M. L. Fuller.

I send a few notes relative to the formation of snow rollers in the village of Canton on February 19, 1907.

The conditions attending the formation of the rollers were as follows :—

Upon a dry and evenly distributed snow covering of 4 ins. depth there fell late in the forenoon of the 19th a half inch or more of fine, dry snow. After 1 p.m. the falling snowflakes were of greater size, becoming large, moist, and feathery after 3.25 p.m. and continuing to 4.25, by which time a total of about one inch had fallen. Light snow with about one-tenth inch of dry sleet occurred from 4.25 to 6.55 p.m.

The temperature, from 10° F. at the 8 a.m. observation, increased to 17° by 3.15 p.m. ; then rose suddenly to 31° at 3.30, and slowly to 34° by shortly after 6 p.m., from which maximum it fell to 17° by 7.15 p.m.

This abrupt rise of temperature and brief thaw accompanied a South-west wind with a velocity of 30 to 40 miles per hour that burst suddenly upon this locality at 3.25 p.m., displacing the North-easterly winds of 4 to 12 miles of the morning and mid-day, which had continued practically up to that hour.

Though the formation of the rollers was not witnessed, so far as ascertained, it is known to have occurred between 5 and 6 p.m. Small rollers were found next morning in a variety of locations. The largest had been developed on a sloping lawn where the strong wind, striking the exposed side of a large cottage, had swept downward and away, rolling the snow downhill. Here the largest attained diameters and lengths of 10 to 12 ins. In structure they closely resembled rolls of cotton batting, but the centres were almost invariably shorter than the outer layers. The layers were plainly marked, and varied somewhat in thickness, averaging probably three-fourths of an inch or more, and being usually thinner near the axis. In occasional instances the centres were very short or almost wanting, and the rolls, although firm enough next morning to be handled, were much lighter than snowballs of the same size when rolled by

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hand, thus indicating but slight packing of the snow in the wind rollers (Fig. 4).

From the conditions observed in this instance, it would appear that the flakes of a light fluffy layer of surface snow are made adhesive by a sudden rise in air temperature, while the under snow still remains cold and dry, and the particles of damp surface snow are enabled to adhere to each other, but not to the dry under snow. A strong wind may then push over little prominences or projections of the surface snow, and start them rolling, when of course they will continue to travel and grow until the resistances overcome the propelling power of the wind.

Miss Ione A. Jillson subsequently reported having once witnessed the formation of snow rollers, and at the suggestion of the writer contributes the



FIG. 4.—Snow Rollers at Canton, N.Y., February 20, 1907.

following account. As its author appears to be habitually careful and painstaking in both observation and statement, the description is thought to be of value:—

"During the winter of 1895 I watched the formation and progress of so-called snow rollers. The temperature was probably a trifle above the freezing point, following a snow-storm characterised by very large light flakes. For the most part the wind seemed to sweep downward and get under a slightly projecting mass of snow, and set it in motion. As the roll grew in size the speed, at first very rapid, slackened, until the mass became too compact and heavy to be moved farther. Sometimes a triangular-shaped "card" of snow, often 3 or 4 ins. across the base, would rise and fall several times before the wind gained sufficient purchase to turn the point over and start the roller. This card looked very much like the corner of a piece of paper as it rises and falls with the wind

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just before it is blown away. The snow seemed to be of an unusual consistency, rendering it tough and flexible.

"These rollers were observed at Edenton, St. Lawrence County, N.Y."

DISCUSSION.

Mr. H. MELLISH remarked that he had observed the phenomena several times at his own place. Last winter he had seen it on three occasions, one of which was on the morning referred to in Mr. Browett's paper, although he lived seventy miles from Coventry where Mr. Browett had observed the snow-rollers. The other two occasions were in connection with the Christmas snowstorms. Snow fell on Christmas night 1906, and on the following night snow-rollers were formed in great abundance. These were first noticed in the moonlight, and in the morning there were a great many of them, the largest being 16 inches in diameter by about 1 foot long, and with hollow ends and short centre; the centre in some had altogether disappeared. Snow fell again that evening, and on the morning of the 28th more rollers were found, also on January 29. As regards the conditions, nearly all the accounts referred to the light fluffy snow falling, followed by a temperature just above freezing point. He had looked at the thermograph last year on each of these three occasions, and on each the minimum temperature occurred in the early evening, being followed by a considerable rise before midnight. On January 26 the temperature fell to 17° soon after sunset, and rose later in the evening to 33°. The following night it fell to 24° (between 5 and 6 p.m.) and rose afterwards to 34°. On the third occasion it fell to 30°·4, which was not so low as previously, and then rose to 35°. It therefore appeared that a necessary condition for the formation of these snow rollers was a temperature slightly above freezing following a rather cold one.

Mr. J. E. CLARK remarked that one interesting point about these snow rollers was, their extreme lightness when compared with similar rolls made by hand. He thought that the wind lifting the rolls would account for this. It would have been interesting to see whether the weight of the rolls on the other side of the slope would have been greater. Possibly the larger number of rolls on the slope from the wind indicated that the wind had got right under them. The wind must have been sufficient to raise the balls as they rolled. The remarkable zig-zag showed the force of the wind, as it no doubt meant that the rolls were reversed endways. If that cylinder were examined it would be found, probably, to have three separate axes.

Mr. C. BROWETT, in reply, thanked those present for their kind appreciation of his paper. As regards the description of the snow rollers he quite agreed with the last speaker. It was a strange thing that none of them should have been on the field facing the wind, while a great number were on the field inclining towards the wind. He also remarked that the most noticeable characteristic of the little vortices that undoubtedly caused the snow rollers, was their persistency independently of the main wind current, and that they were not dissipated by striking against the house, but rebounded directly against the main wind current, though they were not then strong enough to produce actual rollers.

THE PRESIDENT, in thanking Mr. Browett for his very interesting account, said that the ingeniously constructed plan of the snow roller was one of the neatest examples of coping with an unexpected meteorological phenomenon he had seen.

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COMPARISON OF SHIPS' BAROMETER READINGS WITH THOSE DEDUCED FROM LAND OBSERVATIONS; WITH NOTES ON THE EFFECT OF OSCILLATORY MOTION ON BAROMETER READINGS.

By ERNEST GOLD, M.A., F.R.Met.Soc.

(Communicated by the Director of the Meteorological Office.)

[Read February 19, 1908.]

Preliminary Note by Dr. Shaw.

In plotting, upon the working charts of the Meteorological Office, the observations received from the ships of H.M. Navy by wireless telegraphy within the past year, discrepancies have been noticed on various occasions between the pressure readings and those which would have been anticipated from the distribution of pressure over the adjacent land areas. In not a few instances, to have drawn isobars over the sea in strict accordance with the observations thereon would have introduced such contortions into the generally smooth run of the curves that the alternative of disregarding the observations seemed to offer a course more in accordance with official experience of nature. Yet in many cases, after being referred to the ship for confirmation or correction, the observations were returned duly confirmed. It had also come to my knowledge that the discrepancies between ships' readings of pressure in the Indian Ocean and neighbouring land readings were the occasion of some difficulty in the interpretation of the results. At the same time, having regard to the investigations of Sir G. Stokes upon ships' barometers, errors exceeding the hundredth of an inch could not be regarded as accounted for by instrumental difficulties. In order to obtain further information I utilised the occasion of Mr. Gold's presence at the Office for some days at the commencement of this year to obtain a comparison between the barometer readings of a number of ships of the Mercantile Marine, which keep a four-hourly log for the Meteorological Office, and the simultaneous values of the pressure as deduced from the readings of barometers ashore. Mr. Gold has made the question the subject of the report which follows.

It will be understood that the inquiry is still in the preliminary stage. For many reasons the differences are not ordered with any regularity, and conclusions based upon the general trend of mean values showing considerable diversity among themselves are liable to modification. There is, however, sufficient evidence to show that the subject deserves further consideration, and it is with the hope of eliciting assistance from those who are practically interested in observations at sea that the paper is placed before the Society.—W. N. Shaw.

A Comparison of Barometric Readings on Land and Sea.

The following is a preliminary investigation into the relation between the barometer readings taken on ships during their passage across a line

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between Falmouth and Brest, and the readings deduced for the ships' position from the observations at these places and the trend of the isobars, on the assumption of regular pressure changes. Such an investigation is made desirable in view of the introduction of ships' readings into daily weather charts, as well as from the standpoint of the different land and water effects on the atmosphere. The investigation serves the further purpose of testing the readings taken on board ship on the assumption that the land observations are correct.

The materials for the investigation were taken from meteorological logs at the Meteorological Office. The logs were kept mainly by officers in the merchant service, a few on ships of His Majesty's Navy.

The barometer readings on the ships were taken without exception from Kew pattern mercury barometers reading in general to ·005 in. The barometers have their tubes constricted to prevent pumping, and are all certified at Kew before issue, and are from time to time compared with standards at the Meteorological Office. The index error is never greater than ± ·015 in., and is generally less, at all parts of the scale.

The readings entered in the log are the actual readings taken, with no correction whatever applied; the simultaneous reading of the attached thermometer is in all cases entered alongside the barometer reading. For the purposes of comparison the readings have been reduced to 32° F., and to actual sea-level. The gravity correction has not been applied.

The readings at Falmouth are the hourly readings of the photographic self-recording barograph, corrected by comparison with the eye-readings of a standard instrument. They are published reduced to 32°, and a correction of ·19, ·20, or ·21 in. has been applied to reduce them to mean sea-level. The difference between mean sea-level and actual sea-level does not exceed 10 ft. The readings at Brest are taken three times daily—at 7 a.m., noon, and 8 p.m. They are published reduced to 32°, and a correction of ·24, ·25, or ·26 in. has been applied to reduce them to mean sea-level. The readings for Brest at the time of the ship's observation have been obtained by interpolation when these times differed from those of the Brest observations. The results for 4 a.m. and 4 p.m. have been diminished by ·01 in. to allow for diurnal variation.

The latitude and longitude of the ship have been obtained by dead-reckoning from the nearest noon observation, or from the time when the ship was at some known spot, off Ushant or Eddystone in general. The maximum error of position probably does not exceed 10 miles in any direction. The maximum error therefore in the deduced barometer reading, if the pressure distribution were regular, would not exceed ·02 in., and would generally be much less than this. Falmouth is in lat. 50° 9′ N., long. 5° 4′ W.; and Brest, lat. 48° 24′ N., long. 4° 30′ W.

In the accompanying tables are given the particulars of the observations used. The first five columns give the date, time, position, and ship at which the observation was made. Of the four columns of barometer readings, the 1st gives the reading taken on the ship reduced to 32° and to sea-level. The 2nd and 3rd columns give corresponding results for Falmouth and Brest. The 4th column gives the result deduced from the Falmouth and Brest results for the position of the ship. The remaining columns give the wind observed on the ship, the direction and velocity of the ship, the temperature as given by the dry bulb at the ship

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and at Falmouth, and the wind recorded at Falmouth respectively. The velocities are all in miles per hour.

An examination of the tables shows that the pressure, as recorded on the ship, is in nearly all cases considerably less than that deduced from the land observations. The magnitude of the difference varies between wide limits, and at first sight does not appear to follow any law. The results were therefore plotted in various ways, and the diagrams I. and II. obtained.

In Fig. 1 the approximate velocity of the wind relative to the ship

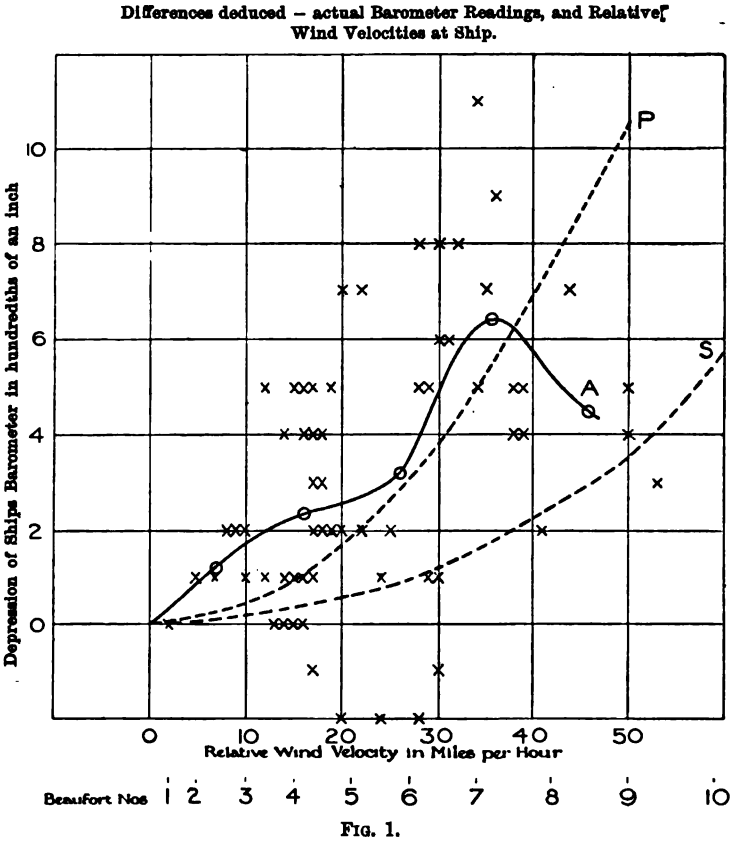


FIG. 1.

is taken as abscissa, and the corresponding depression of the ship's barometer in hundredths of an inch as ordinate. The dotted curve is drawn through the mean points for observations in which the relative wind was between 0 and 10, 10 and 20, etc., miles per hour.

The curve (A) represents the relation between the pressure in hundredths of an inch of mercury and the wind velocity, according to the well-known experimental formula $p = \cdot 003V^2$, or in our units, $p = \cdot 000042V^2$.

Dr. Stanton, Superintendent of the Engineering Department of the National Physical Laboratory, has kindly communicated the result of

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experiments on models at the National Physical Laboratory for the depression produced in buildings in which the lee-side doors were open while those on the windward side were closed. The result may be expressed by the formula $p = \cdot 000014V^2$, where p is in inches of mercury and V in miles per hour. The curve S has been drawn to represent this relation.

The barometer on board ship is usually hung in the chart-room, which for purposes of ventilation and convenience generally has the door on the lee-side open, while that on the windward side is closed. In

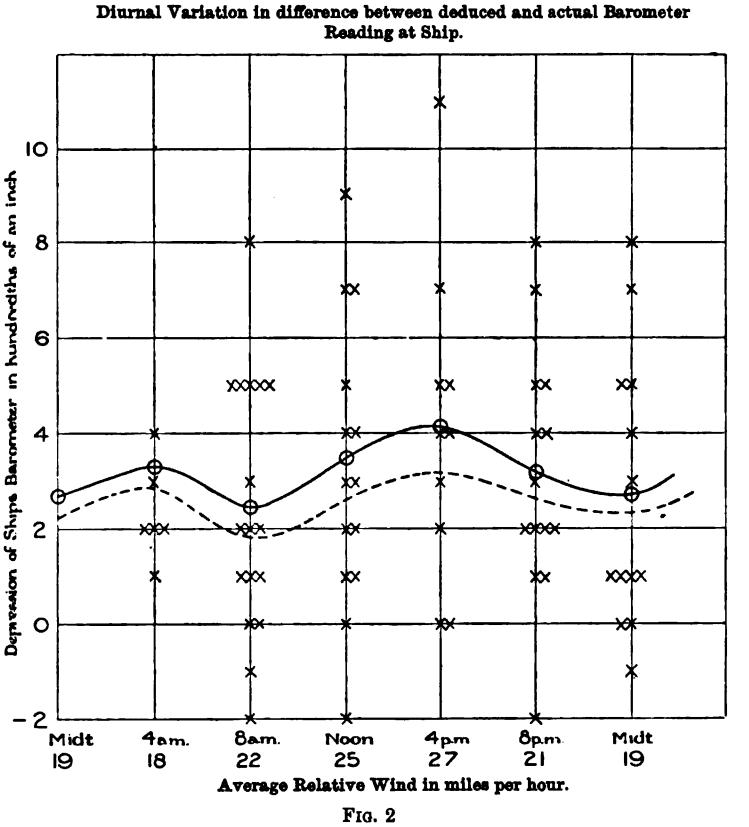


FIG. 2

very high winds both doors may be closed, and any depression caused by the wind can only be due to ventilation. An inspection of Fig. 1 shows that there is on the average a connection between the wind velocity and the barometric depression, but the depression is much larger than would be given by the theoretical curve S. The results roughly correspond to a systematic depression of ·02 in., on which is superposed the depression caused by the relative wind. There are few observations at the higher velocities, but there is a distinct indication of a falling off in the magnitude of the depression corresponding to the closing of the lee-side door.

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The results were also plotted according to the time at which the observation was made; Fig. 2 gives the result. There is a small semi-diurnal variation in the mean value of the depression. To eliminate as far as possible the effect on the barometer reading of a diurnal variation in the relative wind velocity, the amount of the depression as given by the curve S for the mean wind velocity at the various hours has been subtracted from the average depression. In this way the dotted curve was obtained, which still shows the double variation.

There is a noticeable grouping of the values of the depression about particular values in the night and early morning observations. In the day-time the results are more evenly distributed. It has been suggested that the large errors are probably due to the observer reading his instrument ·05 in. too low. Such an error is not uncommon even at land stations, and arises through the peculiar method of graduating English barometers in tenths and half-tenths. The observer reads the correct tenth and the correct vernier reading, but omits to add on at times the ·05. If this were the case with the readings under consideration, it would be natural to suppose that a majority of the cases in which the error exceeded ·05 in. would occur when the second figure after the decimal place in the actual reading was less than 5. An inspection of the actual readings proved that there was no such tendency; the number of cases in which this was 1 to 4 was nearly exactly equal to the number in which it was 6 to 9, both for large and for small relative velocities. There is a preponderance of cases in which this figure is 5, 6 out of 31; but this could not materially affect the result, and we are forced to conclude that the depression is not due to any considerable extent to accidental errors of reading.

From the temperatures given for 1903, it appears that in the majority of the observations the temperature at the ship was higher than that at Falmouth. At the same time, the wind velocities over the sea were considerably greater than those recorded at Falmouth. The wind velocities are in miles per hour, those for Falmouth being converted from the Robinson anemograph by using the factor 2·2, while for the ship the table of conversion for single observations, as given in Simpson's report, is used.

There does not appear to be any marked connection between wind direction and the value of the depression, except that for South winds (S.S.E. to S.S.W.) the mean value is about half the average value for other directions.

A comparison of some of the values with the height of the tide did not reveal any connection, but it is possible that the averaged depressions corrected for wind velocity effect would rise and fall with the tide.

There is another effect (on the height of the ship's barometer) which may be of appreciable magnitude, namely, that due to the vertical acceleration as the ship passes over a series of long waves. If the ship is moving across the waves with velocity V relative to them, we may represent the height of the barometer above mean sea-level at any instant by $y = a \sin \frac{2\pi}{\lambda} \mathrm{V}t$, where λ is the wave length.

The vertical acceleration at any instant is therefore

$$\ddot{y} = -a \cdot \left(\frac{2\pi \mathrm{V}}{\lambda}\right)^2 \sin \frac{2\pi}{\lambda} \mathrm{V}t.$$

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TABLE OF BAROMETRIC READINGS ON SEA AND ON SHORE.

Date.	Time.	Ship.	Lat.	Long.	Barometer reduced to Sea-Level and 32° F.			Barometer at Ship deduced from Falmouth and Brest.	Wind at Ship.	Ship's Velocity.	Temperature.		Wind at Falmouth (2·2 factor).
					Ship.	Falmouth.	Brest.				Ship.	Fal-mouth.	
1901			° ′	° ′	ins.	ins.	ins.	ins.			°	°	
Nov. 5	4 a.m.	Harold	49 10	4 30	*30·29	30·34	30·28	30·31	*ESE 21	S 56° W 9	54	51	E by S 6
5	8 a.m.	Harold	48 54	5 5	*30·33	30·38	30·32	30·34	*E 15	S 56 W 8	52	50	E by N 5
1902													
Mar. 2	12 noon	Montrose	48 38	4 59	*29·93	29·90	29·96	29·95	*W by S 10	S 52 W 13	*53	48	WSW 7
May 10	12 noon	Montrose	48 32	5 8	*30·20	30·21	30·17	30·18	*NE 15?	N 39 E 11	*55	50	SE by S 4
Aug. 8	8 a.m.	Alcinous	49 53	4 30	*29·87	29·87	29·91	29·88	*SW —	...	59	60	Calm
8	Noon	Alcinous	49 49	4 41	*29·93	29·92	29·94	29·93	*Calm	...	64	63	NW 7
8	4 p.m.	Alcinous	49 42	4 50	*30·00	29·98	30·02	30·00	*WNW 15	...	63	61	N by W 11
22	8 p.m.	Arcadia	49 0	5 7	*30·15	30·14	30·21	30·17	*SSE 5	S 49 W 17	*60	60	SSW 7
30	Midnight	Omrah	49 10	4 59	*29·77	29·78	29·89	29·85	*SSW 15	S 27 W 14	61	57	SE by S 9
Sept. 25	,,	East Point	49 45	5 0	*30·45	30·46	30·44	30·45	*NW 2	W 12	*59	54	... 3
28	4 a.m.	Walmer Castle	49 9	4 28	*30·35	30·41	30·38	30·39	*N 2 W 2	S 49 W 19	*59	55	... 3
Oct. 2	Noon	Matatua	48 30	5 11	*29·91	29·84	29·99	29·96	*NE by N 21	S 30 W 9	*67	57	NE by E 10
25	Midnight	Orontes	49 0	5 10	*30·35	30·33	30·39	30·36	*S 1 W 10	S 32 W 15	*54	50	SSW 7
28	8 a.m.	East Point	49 40	5 10	*30·15	30·10	30·18	30·13	*S by E 15	E 11	*56	55	... 2
Nov. 14	8 p.m.	Walmer Castle	49 18	4 10	*30·28	30·31	30·30	30·31	*ENE 5	N 47 E 15	*55	52	SSE 7
14	8 p.m.	Britannia	49 0	4 20	*30·29	30·31	30·30	30·31	*E 7	S 50 W 14	51	52	SSE 7
22	Noon	China	49 39	4 29	*29·98	29·94	30·07	30·00	*S 27	S 48 W 18	*52	53	S by W 11
28	4 p.m.	Arcadia	49 25	4 58	*29·27	29·28	29·36	29·32	*W 15	N 26 E 16	*52	46	SW by S 8
30	8 a.m.	Walmer Castle	48 40	5 5	*29·43	29·49	29·48	29·48	*N 3 W 10	S 30 W 18	*51	44	N 4
Dec. 5	4 a.m.	Omrah	49 5	5 0	*30·37	30·44	30·42	30·43	*E by S 21	N 36 E 15	44	34	NE by N 4
12	8 p.m.	Arcadia	49 0	4 55	*29·97	29·93	30·01	29·98	*S 1 W 15	S 54 W 16	*52	44	SW by W 5
14	8 p.m.	Assaye	49 12	4 45	*30·02	29·85	30·14	30·00	*SSE 35	N 34 E 15	*55	54	S by W 29
20	8 p.m.	Omrah	50 0	4 30	*30·42	30·48	30·52	30·49	*W 10	S 30 W 14	*54	52	NW by N 9
20	Midnight	Omrah	49 0	5 0	*30·48	30·50	30·54	30·52	*NW 10	S 30 W 14	*54	52	NW by N 11
26	Noon	India	49 28	4 17	*30·32	30·38	30·46	30·41	*WNW 27	SW 15	*52	51	WNW 15
26	4 p.m.	India	48 50	5 10	*30·37	30·37	30·44	30·44	*WNW 27	SW 14	*52	50	WNW 15

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1903															
Jan. 4	Midnight	Montrose	49	18	4	34	*29·76	29·67	29·88	29·75	*SW by S 27	N 38 E 11	*55	53	SW 28
16	4 p.m.	Walmer Castle	48	50	5	0	*29·79	29·92	29·94	29·90	*SE 35	N 30 E 15	*47	42	SSE 22
29	4 a.m.	China	49	30	4	50	*30·47	30·46	30·53	30·50	*WNW 21	N 23 E 16	*50	44	W 8
30	4 a.m.	Orontes	50	1	4	43	*30·42	30·41	30·49	30·43	*SSW 21	N 40 E 11	*49	45	SW by W 10
31	4 p.m.	Egypt	48	46	5	0	*29·62	29·55	29·71	29·67	*SSW 35	S 42 W 16	*52	46	S 21
31	Noon	Egypt	49	30	4	0	*29·84	29·79	29·92	29·87	*SW by W 35	S 42 W 19	*53	51	S by W 20
Feb. 1	Noon	Walmer Castle	49	0	4	45	*29·50	29·48	29·62	29·57	*WNW 35	S 50 W 13	*42	40	W by S 16
5	8 a.m.	Moravian	48	20	6	5	*30·34	30·37	30·43	30·40	*S by E 15	S 28 W 13	*54	48	SSW 10
14	Midnight	Orontes	49	15	5	10	*30·26	30·24	30·29	30·27	*WNW 5	S 30 W 14	*48	46	NW by N 6
20	8 a.m.	Britannia	48	32	5	38	*30·53	30·44	30·56	30·53	*SW by W 12	N 26 E 15	*55	51	WSW 6
21	4 p.m.	China	49	20	4	54	*30·21	30·14	30·37	30·25	*SW 35	S 49 W 15	*54	54	W by S 24
23	8 a.m.	Sophocles	49	0	5	0	*29·91	29·84	29·99	29·96	*W 27	N 23 E 12	*47	40	W by S 16
Mar. 13	8 p.m.	Britannia	48	50	4	45	*29·90	29·91	29·93	29·92	*N 10	S 50 W 13	48	44	... 1
15	8 p.m.	Orient	49	0	4	50	*29·65	29·62	29·77	29·73	*SSW 21	S 50 W 13	*48	44	SSW 15
20	Noon	Arcadia	49	29	4	49	*30·35	30·29	30·44	30·36	*S by W 15	N 26 E 16	*53	52	SW by W 19
20	4 p.m.	Walmer Castle	49	1	4	12	*30·30	30·29	30·40	30·36	*SSW 10	N 48 E 16	*54	51	SW by S 18
27	4 a.m.	Omrah	49	0	5	0	*29·42	29·44	29·50	29·48	*NW by W 21	N 30 E 16	*49	41	W 8
Apr. 9	8 a.m.	Egypt	49	26	4	50	*30·27	30·28	30·28	30·28	*N 15	N 32 E 16	*50	47	N by E 6
25	8 p.m.	India	49	0	4	58	*29·64	29·64	29·72	29·69	*WSW 15	S 53 W 15	*51	49	S by W 13
25	Midnight	Ormuz	49	7	5	10	*29·57	29·58	29·66	29·62	*SSW 27	S 26 W 13	*50	47	S by W 14
26	Midnight	Orient	49	20	4	40	*29·29	29·26	29·39	29·32	*WNW 10	N 22 E 14	*50	48	WSW 10
May 7	8 p.m.	Britannia	48	51	5	14	*29·67	29·65	29·69	29·68	*SE 10	N 32 E 13	54	51	S by E 9
7	Midnight	Britannia	49	35	4	42	*29·63	29·61	29·65	29·63	*SE 10	N 25 E 13	54	51	SSE 14
15	8 p.m.	Victoria	49	18	4	50	*30·29	30·31	30·36	30·33	*NW 5	N 23 E 15	52	48	WNW 6
22	Noon	Hibernian	48	21	5	12	*30·11	30·08	30·12	30·12	*NW by W 10	N 22 E 12	*54	58	SW by W 15
22	4 p.m.	Hibernian	48	53	4	20	*30·17	30·13	30·18	30·17	*NW by W 10	N 48 E 13	*55	60	SW by W 13
23	4 a.m.	Orontes	49	55	4	35	*30·33	30·35	30·34	30·35	*WNW 15	N 55 E 10	*52	48	NW by N 4
28	8 a.m.	China	49	30	5	8	*29·88	29·92	29·85	29·90	*NE 15	N 28 E 13	*55	58	N by W 7
31	Noon	Moravian	49	22	4	48	*29·80	29·82	29·85	29·84	*NNW 2	N 28 E 13	*57	63	N by W 10
June 6	Midnight	Orontes	49	50	4	30	*30·23	30·30	30·20	30·28	*ESE 15	S 32 W 14	*53	53	E 4
27	Noon	Victoria	49	26	4	21	30·09	30·08	30·09	30·09	Calm	S 42 W 18	65	65	SE 7
July 1	Midnight	Moravian	49	35	5	2	*30·08	30·16	30·12	30·15	*SE 15	S 40 W 13	*58	57	ESE 5
4	8 a.m.	Albertville	48	59	4	44	30·22	30·20	30·26	30·24	W by S 2	S 50 W 13	*61	59	SW by W 4
18	Midnight	Orient	49	5	5	4	*29·84	29·83	29·86	29·85	*SW 5	S 30 W 13	*61	56	... 2
25	4 p.m.	India	48	45	5	1	29·73	29·73	29·85	29·74	S 21	S 53 W 16	61	61	S by W 12
26	8 a.m.	Arcadia	49	17	4	56	*29·86	29·89	29·96	29·91	*WNW 5	N 26 E 16	*61	60	WNW 10

* The Observations marked with an asterisk in the Tables are taken from logs which have been classed by the Meteorological Office as "excellent" or "very good" for these particular observations. The diagrams have been prepared from the rows of observations in which the barometer reading is so classed.

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TABLE OF BAROMETRIC READINGS ON SEA AND ON SHORE—(*Continued*).

Date.	Time.	Ship.	Lat.	Long.	Barometer reduced to Sea-Level and 32° F.			Barometer at Ship deduced from Falmouth and Brest.	Wind at Ship.	Ship's Velocity.	Temperature.		Wind at Falmouth (2·2 factor).
					Ship.	Falmouth.	Brest.				Ship.	Fal-mouth.	
1903			° ′	° ′	ins.	ins.	ins.	ins.					
Aug. 1	4 p.m.	Egypt	49 10	4 43	30·13	30·12	30·19	30·16	SW by W 10	S 47 W 15	*61°	64°	NW by W 8
16	4 a.m.	Ormuz	48 20	4 50	29·92	29·86	29·99	29·99	WSW 30	S 47 W 13	57	53	W 10
17	8 a.m.	Ramsay	49 10	4 4	*29·75	29·74	29·91	29·80	*W by S 35	S 56 W 6	*60	58	NW 15
17	Noon	Ramsay	49 0	4 24	*29·88	29·85	29·98	29·92	*W by S 35	S 56 W 5	*61	60	NW by W 15
17	4 p.m.	Ramsay	48 45	4 54	*29·93	29·89	29·99	29·97	*SW by W 15	S 56 W 7	*61	59	W by S 11
21	4 a.m.	Albertville	48 45	4 58	29·57	29·58	29·69	29·66	SW by W 21	N 47 E 13	*60	52	N 8
21	Midnight	Maine	49 5	4 33	29·93	29·90	29·94	29·93	W by N 21	S 55 W 12	*61	60	... 3
Sept. 5	8 a.m.	Albertville	48 57	4 26	29·84	29·80	29·90	29·87	W by S 5	S 50 W 13	*60	58	W by N 13
9	Midnight	Soudan	49 40	5 20	30·18	30·18	30·22	30·19	WNW 21	S 43 W 12	56	52	NW by N 8
11	8 a.m.	Orontes	49 55	4 30	*29·63	29·69	29·79	29·71	*NW 25	N 35 E 16	*55	50	NW 15
19	8 p.m.	Alnwick Castle	49 16	4 22	29·86	29·92	29·82	29·87	E 27	S 52 W 13	*58	56	E by S 11
24	8 a.m.	Egypt	49 10	4 50	30·23	30·25	30·25	30·25	Calm	N 27 E 16	*59	57	... 3
29	4 a.m.	Ramsay	49 0	4 13	*29·69	29·62	29·72	29·71	*S 15	N 54 E 10	*58	57	SSW 5
Oct. 3	Midnight	Victoria	49 35	4 45	29·75	29·72	29·88	29·80	SW 10	N 23 E 15	60	58	SSW 18
4	8 a.m.	Courtfield	49 1	5 3	*29·85	29·77	29·87	29·84	*WSW 21	S 43 W 12	*60	56	W by S 8
25	8 a.m.	Albertville	48 55	4 46	29·28	29·23	29·39	29·34	S 42	N 43 E 13	*57	54	S by W 19
30	8 a.m.	Moravian	49 30	4 45	*29·95	29·93	30·02	29·97	*W 21	N 24 E 13	*56	49	WNW 9
31	8 p.m.	Victoria	48 57	5 29	*29·97	29·93	30·06	30·02	*W 15	SW 16	*57	53	W by N 15
Nov. 7	4 a.m.	Albertville	49 0	4 30	30·34	30·40	30·36	30·38	SE 27	S 51 W 12	51	51	ESE 10
7	8 p.m.	Ophir	49 56	4 27	30·31	30·36	30·33	30·35	E by S 21	S 28 W 11	...	51	E by S 8
10	Midnight	Soudan	50 3	4 30	30·38	30·39	30·44	30·40	WSW 21	ENE 13	52	50	... 4
20	4 a.m.	Ormuz	50 0	4 40	30·28	30·31	30·34	30·31	NW 5	N 40 E 13	49	42	W 6
28	Midnight	India	48 50	5 15	29·23	29·20	29·25	29·24	NW 30	S 57 W 13	50	44	NNW 11
†Dec. 3	Noon	Alnwick Castle	48 47	4 55	†30·20	29·95	30·14	30·07	SE 5	NE 13	*48	45	SSW 23
27	Noon	Albertville	48 40	5 0	29·94	30·05	30·02	30·03	E 21	NE 12	45	40	ENE 8

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1906															
Aug. 14	8 a.m.	Loch Torridon	49	45	4	50	*29·61	29·61	29·66	29·63					
14	6 p.m.	Loch Torridon	49	55	5	15	*29·67	29·67	29·75	29·68					
15	8 a.m.	Loch Torridon	49	30	5	30	*29·82	29·79	29·86	29·82					
Dec. 7	8 a.m.	Wakanui	49	10	4	42	*30·32	30·43	30·28	30·35					
20	4 p.m.	Shadwell	48	50	4	45	30·47	30·56	30·48	30·50					
31	8 p.m.	Tongariro	49	25	4	55	*29·69	29·71	29·76	29·73					
1907															
Jan. 12	4 p.m.	Macedonia	49	20	4	20	*30·68	30·69	30·74	30·71					
19	Noon	Wellington	50	54	5	50	*30·43	30·54	30·53	30·50					
26	8 p.m.	Ophir	50	0	4	35	30·62	30·65	30·55	30·64					
Feb. 9	8 p.m.	Omrah	49	53	4	20	29·83	29·86	29·88	29·86					
10	8 p.m.	Athenic	49	40	4	40	29·72	29·70	29·80	29·73					
12	Midnight	Maori	49	20	4	44	29·47	29·50	29·54?	29·52?					
Apr. 15	4 p.m.	Wakanui	48	50	5	0	*29·57	29·60	29·58	29·59					
16	4 p.m.	Shadwell	49	0	4	50	29·61	29·61	29·61	29·61					
25	8 a.m.	Mooltan	49	4	5	0	*30·31	30·35	30·37	30·36					
25	Noon	Mooltan	49	45	4	30	*30·27	30·34	30·32	30·33					
25	Midnight	Tongariro	49	25	5	1	*30·19	30·21	30·19	30·20					
May 3	Noon	Ophir	49	5	4	54	*29·60	29·53	29·71	29·63					
17	4 a.m.	Omrah	49	45	4	30	30·19	30·22	30·18	30·21					
June 5	8 a.m.	Athenic	49	45	4	50	29·72	29·74	29·79	29·75					

* The Observations marked with an asterisk in the Tables are taken from logs which have been classed by the Meteorological Office as "excellent" or "very good" for these particular observations. The diagrams have been prepared from the rows of observations in which the barometer reading is so classed.

† Probably Ship's barometer incorrect. Same reading was entered several times consecutively.

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If this condition were permanent the height of the barometer would be $h \cdot \frac{g}{g+\ddot{y}}$, where h is the true height and g the acceleration due to gravity.

If the period be not too small, the motion of the mercury in the constricted tube of the barometer will satisfy an equation

$$\frac{dx}{dt} + q\left(x - \frac{gh}{g+\ddot{y}}\right) = 0,$$

where q is a constant, and x represents the height of the barometer.

In general $\ddot{y}$ will be small compared with g, and we may write this equation

$$\frac{dx}{dt} + q\left(x - h - \frac{ha}{g} \cdot \left(\frac{2\pi V}{\lambda}\right)^2 \sin \frac{2\pi V t}{\lambda}\right) = 0,$$

whence

$$x = h + \beta \sin\left(\frac{2\pi}{\lambda} V t + \epsilon\right)$$

and

$$\beta = q \cdot \frac{ha}{g} \cdot \left(\frac{2\pi V}{\lambda}\right)^2 \times \frac{1}{\sqrt{q^2 + \left(\frac{2\pi V}{\lambda}\right)^2}}$$

The barometric height therefore oscillates, and the amplitude of the oscillation is β.

Taking $q = \frac{1}{240}$ corresponding to a lagging time[1] of four minutes, a to be 10 feet, $\frac{2\pi V}{\lambda} = \frac{1}{30}$, we get

$$\beta = \frac{1}{240} \cdot \frac{1}{30} \cdot \frac{10h}{32} \text{ approximately,}$$

which is only slightly greater than $\frac{1}{1000}$ of an inch.

For waves 100 yards long in deep water, the wave velocity is about 38 feet per second, and the period about $7\frac{1}{2}$ seconds. If a ship steaming 17 knots is meeting such a series of waves we should get $\left(\frac{2\pi V}{\lambda}\right) = 4$ seconds approximately, and the corresponding value of β would be given by

$$\beta = \frac{1}{240} \cdot \frac{1}{4} \cdot \frac{10h}{32} = \cdot 01 \text{ in. approximately.}$$

The height of the barometer would therefore oscillate through a range of ·02 in.; for a greater value of a the range would be proportionally larger.

The effect of the inertia of the mercury has been neglected; its introduction would change t slightly, but would affect the value of β only by changing q in the expression under the square root into $q\left\{1 - \frac{h}{g}\left(\frac{2\pi V}{\lambda}\right)^2\right\}$. This would not materially affect the final value of β, and it can be fairly left out of account.

It may be that in taking the barometer reading at a time when the instrument is "pumping" the observer chooses the instant when the mercury is at its lowest level, and assumes that the correct value is thereby obtained. From the above calculations it would appear that a value so obtained would always be too low, and that a better way would be to observe the highest and lowest readings and to take the mean. It is assumed that the support of the barometer is such as to enable it to

[1] See *Report of the Meteorological Council*, 1880, p. 28.

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retain its vertical position, and that its free period of swinging is much smaller than the period of the oscillation of height.

We may investigate the approximate effect of swinging on the barometric height in the following way. The effect produced by swinging is due partly to the upward thrust of the atmospheric pressure when the barometer is inclined, and partly to the outward centrifugal tendency owing to the rotation about the axis.

Let x be the actual length of the mercury column at any instant, let h be the true barometric height for the barometer under consideration, $\frac{1}{q}$ its lagging time, θ its inclination to the vertical, k the distance of the centre of the mercury column below the point of support. Then we may write the equation of motion of the column in the form

$$\frac{q}{g}\ddot{x}A\int\frac{dh}{a}+\frac{q}{g}\cdot h\cdot k\dot{\theta}^2+\dot{x}+q(x\cos\theta-h)=0,$$

where a is the cross-section at any point and A that at the upper end. For barometer tubes there is generally a constriction in the middle of the tube for a considerable part of the length, and consequently $A\int\frac{dh}{a}$ is greater than h. Let us call it h'. Further, let us put $\theta=a\sin pt$ where a is small. The equation of motion may then be written

$$\frac{qh'}{g}\ddot{x}+\dot{x}+q\Big\{x-h-\frac{xa^2}{4}+\frac{kh}{2g}\cdot a^2p^2+\frac{xa^2}{4}\cos 2pt+\frac{kh}{2g}a^2p^2\cos 2pt\Big\}=0.$$

The solution of this equation is

$$x=h\Big(1+\frac{a^2}{4}-\frac{ka^2p^2}{2g}\Big)+\beta\sin(2pt+\psi),$$

where

$$\beta=\frac{q\frac{ha^2}{4}\Big(1+2\frac{kp^2}{g}\Big)}{\sqrt{4p^2+q^2\Big(1-4\frac{p^2h'}{g}\Big)^1}}.$$

Putting $q=\frac{1}{240}$, $h=2{\cdot}5$ ft., $h'=2h=5$, $\frac{2\pi}{p}=1$, $g=32$, $k=4$ ins. $=\frac{1}{3}$ ft., $a=0{\cdot}1$, in this expression we find $\beta=\cdot00005$ in. nearly.

In this case, therefore, the oscillation is negligible. The mean value of x is, however, given by

$$x=h\Big\{1+\frac{a^2}{4}-\frac{ka^2p^2}{2g}\Big\}$$
$$=h\{1+\cdot0025-\cdot0021\}=h\{1+\cdot0004\},$$

and the barometric height would consequently be about ·012 in. too high.

The actual value of p for a station barometer here[1] is given by $\frac{2\pi}{p}=1{\cdot}5$. The corresponding value for x with a and k as before would be

$$x=h(1+\cdot0025-\cdot0009)=h(1+\cdot0016),$$

and the mean reading would be about ·05 in. too high.

It is not easy to test this for a station barometer because the mercury falls too rapidly if the barometer is brought to rest, but for a marine barometer the test ought not to be difficult. It is to be noted that the range of oscillation alone depends on the value of q and, therefore, on the constriction: the mean value of x is independent of q. From a rough

[1] At Cambridge, Barometer M.O. 963.

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trial the barometer here, M.O. 963, appears to read nearly ·045 in. too high for a swing through an angle corresponding to $a = 0{\cdot}1$ and ·20 for $a = 0{\cdot}2$ in good agreement with the theoretical amounts. Both for swinging and for the rise and fall of the ship some time must elapse before the steady oscillatory state is reached.

Taking into account, therefore, the various causes which can appreciably influence the height of the barometer on board ship, we are compelled to say that until the two chief ones at any rate, the wind and the vertical acceleration effects, are eliminated, it will be impossible to draw any satisfactory conclusions regarding the relative values of atmospheric pressure over sea and land. One can say in general that there appears to be a tendency for the barometric pressure to be lower between Falmouth and Brest than would be expected from the land observations.

DISCUSSION.

Capt. M. W. C. Hepworth said he had listened with a great deal of pleasure to Mr. Gold. He understood that the inquiry was still in a preliminary stage, and hoped Mr. Gold would follow up the investigation which promised to have important results. In carrying on the work he thought Mr. Gold might be able to obtain the assistance of a number of marine observers who would be interested in it and take specially careful observations. He would suggest that the barometric observations should be recorded to three places of decimals; that the position of the ship should be accurately noted—it would not be sufficient accuracy to give the position to within ten miles as stated: captains who were contented to navigate their ships to within a handful of miles in the Channel came to grief. Other details should also be given, such as the direction and force of the wind on the water, as estimated by the observer, and also as he felt it on the ship; the speed of the ship; its motion, and the rise and fall of the vessel with the scud of the sea. Mr. Gold would then have a number of reliable observations to work on. The difficulty of obtaining sufficient observations for the present inquiry arose in consequence of the fact that observers were so busy in the Channel with other duties, that they were not, as a rule, able to commence observations until past Ushant. Mr. Gold considers that this investigation serves the further purpose of testing the readings taken on board ship, on the assumption that the land observations were correct; but he, Captain Hepworth, felt inclined to suggest that the process be reversed! For some twenty years or more he had been in a position to judge of the general accuracy of barometric observation taken by sailors on board ship, and during the last eight years he had had the opportunity of testing the capabilities of land observers in that respect, and he had come to the conclusion that seamen were as good observers as landsmen. With regard to the pumping of the barometer in a seaway, he thought the observations should be taken—that is to say, the vernier set—when the mercury had touched its lowest level, instead of observing the highest and lowest, and taking the mean. With large ships, such as the *India*, referred to by Mr. Gold, there was in the Channel, as a rule, very little pitching and rolling, rise and fall, as they are borne on three waves; so there should be only small errors from these causes. In comparing barometric observations taken at sea with those deduced from land observations taken at some distance off, there was room for a considerable amount of error, but he would let that pass. After all the sources of error which Mr. Gold had told them of had been eliminated, he would still expect to find a difference between

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the sea observations and those deduced from the land observations. If they looked at any of the wind charts of the great oceans, and examined the wind arrows round the coast, they would see that the wind had a tendency to cling to the land. This is shown to some extent on the Daily Weather Charts of the Meteorological Office. Probably Mr. Brodie and his assistants in the Forecasting Branch of the Office, took this into account when watching for the backing wind on the coast of Ireland. Whether the land was high or low there was a tendency for the wind to follow the coast-line in all parts of the world. He thought that, superposed on the general pressure distribution, there existed a gradient between land and sea, and accounted for it in that way. Twenty-five years ago he had first mentioned this fact in a paper he had contributed to the Society.

Dr. W. N. SHAW wished to point out that the question raised in the paper was one of practical scientific importance. As regards the observations, it might be assumed that the observers on land and sea were equally accurate; it was not the competence of the observers that was in question, but the readings which an instrument would give under different conditions, as represented by exposure in an observatory on land and on a ship at sea. The question of barometer readings was not a new one. The Observatory at Ben Nevis had been greatly hampered by the fact that barometer readings had to be rejected —not corrected—when the wind exceeded force 3 on the Ben Nevis scale, because they were too much affected by the wind in those circumstances. That great enterprise was continued for 20 years, and if they considered that meteorology only began to be interesting when the wind got beyond force 3 they would understand the gravity of the question under discussion. In another part of the world a proposal to incorporate land and sea observations, for daily charts, was in danger of being given up because the apparent probable error of an observation at sea was of the order 0·04 in. This state of things ought not to be accepted after fifty years of meteorological study. They were grateful to Mr. Gold for bringing the matter into the light of facts, and enabling them to get some criteria as to the extent of the difference to be expected in different circumstances.

Until the facts of the present inquiry were set out he had supposed that the difficulties of barometric readings at sea or in winds were expressed by what is known as "pumping," but presumably there was a definite pressure difference as well. If he recollected rightly, Professor Cleveland Abbe had described a contrivance for obviating the effect of pumping, by having the barometer in a closed case which communicated with the free air by means of a pipe terminating in a double flange. In view of the information now before us, it would be interesting to consider what the possible effect of wind could be upon a barometer if the position were chosen to exhibit that effect to the greatest extent.

With a barometer in a closed room communicating with the outside by a tube bent to face the wind, the pressure recorded in inches of mercury would be greater than the true pressure in the flowing air by a quantity equal to $\cdot 000042V^2$, as shown by Mr. Gold. This was the maximum interference which could be got with the barometer in consequence of wind blowing directly on the mouth of the communication between the outside air and the room containing the barometer. On the other hand, if they placed a barometer in a closed room, and took up a pipe arranged so that the wind blew across the opening, the effect upon the readings would be of about the same magnitude; but in the opposite direction, the recorded pressure would be less than the true pressure by $\cdot 000042V^2$. These variations amount to about ·05 in. for wind of 35 miles per hour, just reaching gale force. Thus if two barometers were compared, and one were subject to the effect of direct impact of the wind and

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the other to the effect of suction due to cross blowing, they might show a difference of 0·1 inch in a .35-mile wind. This is the greatest amount of difference attributable to such causes even in extreme conditions for a wind of that velocity. If, however, there were two openings, one directly exposed to the wind, and the other having the wind blowing across it, the two acting together therefore, if properly adjusted, would counteract each other and produce no change of pressure at all. The first conclusion from the paper was that they seldom found a barometer exposed under those conditions.

The conditions of actual exposure of two barometers might be anything between the extremes on either side, and thus a comparison of the two for a 35-mile wind might show anything between + 0·1 and − 0·1 according to circumstances.

The next conclusion to be drawn was, that the exposure on board ship as a rule is such, that the barometer readings show the effects of "suction" as compared with the barometer at Falmouth Observatory.

The inquiry is still in a preliminary stage because the number of observations is small. A sufficient number of observations would enable them to tell how to expose a barometer in order to know what the amount of error would be, and therefore what correction would be required.

As regards the last part of the paper, he must thank Mr. Gold for including the solution of the problems of the effect of the rise and fall of the ship in a train of waves, and the effect of a pendular oscillation. It was very convenient to have the magnitude of the errors due to those causes ascertained.

Mr. H. Harries said that Mr. Gold was to be congratulated on the success which had attended his very interesting investigation of a problem, the importance of which had probably not hitherto occurred to meteorologists. Practical experience, however, shows that at many land stations the pressure observations are as unreliable as those taken at sea, similar causes producing similar results. Last Friday evening (February 14) there was a very rapid decrease and increase of pressure on our north-western coasts, accompanied by high winds. At one station, where the barometer is in a hut on a very exposed headland, and with an over-abundance of roof ventilation, the barogram is formed of a series of violent oscillations, producing a curve which at times has a breadth of 0·1 in. or more. At a neighbouring station, where the barometer is suspended in the observer's private house, and properly protected against varying air currents, the barogram is a beautifully smooth and regular curve, absolutely free from any irregular fluctuations. Investigation will probably result in proving that all barometers fixed in tall, chimney-like structures, such as lighthouse towers, read too low in consequence of an up-draught, which in lighthouses would be greatly strengthened by the heat from the illuminating machinery on the upper floors, reducing the barometric pressure by as much as 0·05 in. These may be described as artificial conditions of exposure, but in Southern Europe we are provided with an illustration of the same thing on a vast natural scale. The Alpine range, rising to between 10,000 and 16,000 feet, towers above the plains of North Italy. When the general atmospheric conditions favour strong Westerly winds and gales above this high wall, so great is the suction of the air from the plains on the lee side that the barometer readings at Turin, Milan, Cremona, Verona, and other observatories, are not only hundredths, but actually tenths of an inch lower than if the Alpine barrier did not exist. On the other hand, when the conditions produce a steady flow of easterly wind, such an excess of air becomes imprisoned within the basin that the barometer rises very much higher at these stations than at neighbouring ones on the French side of the Alps.

Mr. R. Inwards remarked that it did not seem to him impossible to get more extended experiments by means of Marconigrams, or other signals—say on

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a voyage along the coast of Portugal so as to take land and sea observations at the same time. They would then get some really sound facts, and thus prepare the way for calculations and deductions.

Capt. R. C. WARDEN remarked that he had been very interested in the point regarding the fluctuations of a ship's barometer. He had had two barometers on board ship, one hanging in the entrance to the staircase, and the other in a cupboard in the chart room. In the China seas, where the barometer was watched with the greatest care during the passage of two typhoons, the observations from the two barometers differed greatly, though in ordinary weather their readings agreed. The barometer on the staircase became quite demoralised for no apparent reason, and the readings were most unreliable. The other barometer gave most accurate results. He was greatly indebted to Mr. Gold for supplying a possible explanation for this fact, as hitherto he had failed to understand why the barometer on the staircase should have become useless; and on behalf of seafaring men he thanked Mr. Gold for his investigations.

Meteorological Work at the Royal Observatory, Greenwich, 1907.

The Meteorological observations by eye and by self-recording instruments have been maintained as usual, and the special observations of clouds on selected days in each month have been continued at the request of the International Balloon Committee, a Fineman nephoscope having been used for this purpose.

Daily reports have been issued as in previous years; weekly meteorological returns furnished to the Registrar-General; monthly returns of temperature, rainfall, and sunshine to the Royal Meteorological Society; and monthly reports (instead of quarterly as in recent years) to the Meteorological Office.

The temperature of the air ranged between 82°·7 on September 25, and 22°·4 on January 24. 1907 was thus the third year having its highest temperature in September, a feature unknown in the first fifty-four years of the Greenwich records; and this highest temperature occurred later than in any other year of the series, that in 1895 being on September 24. The only other daily maximum reaching 80° during the year was 81°·5 on May 12. Instances of readings of 80° and upwards in May only have occurred before, in 1841 and 1862; but 1907 is unique in showing such readings before and after, but not during, what are regarded as the three summer months. The daily maximum reached 80° twice only in 1841 and 1853, once only in 1862 and 1879, and not at all in 1860, when the highest reading, 76°·5, was in May.

Notwithstanding the absence of high temperature readings in the summer the mean temperature for the year was 49°·4, or only 0°·2 below the average for the 65 years 1841-1905, the outstanding months being July 4°·0 below, June 2°·9 below, and March 2°·4 above the corresponding average values.

The duration of sunshine recorded in the year was 1417 hours, the sun having been above the horizon for 4459 hours, so that the total fell short of the average for 1897-1906 by 85 hours. March, however, was the sunniest on record at Greenwich with 170 hours of bright sunshine. The greatest actual duration on a single day was 13·5 hours on June 16, but the greatest percentage was 88·4 per cent on August 28, so that the intensity as well as the duration appears to show a decided falling off in comparison with the exceptional conditions of the preceding year. There were, during 1907, 71 days on which no register of sunshine was obtained, one of these days occurring in each of the months June, July, August, and September.

The highest reading of the solar radiation thermometer with blackened bulb *in vacuo* was 142°·3 on June 9 (again a distinct falling off in comparison

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with 1906), and the lowest reading on the grass was 8°·8 on January 25. The difference between the "highest in the sun's rays" and the "lowest on the grass" exceeded 100° on only 5 days (as against 32 in 1906), the maximum difference, 107°·8, being one of the features of the phenomenally fine Easter Day, March 31.

The number of days when air temperatures of 32° or less were recorded was 45, of which the first three months were responsible for 37, and the cold night of April 18-19 for two more, leaving only six for the end of the year. December with one night-frost (December 15-16), accounting for two of these, was thus on a level with April.

On the ground, the number of days similarly counted with readings of 32° and under was 133. Using the Meteorological Office limit of 30° and under the number of days was 103, which is further reduced to 86 by considering the night as the unit instead of the day.

Rain fell on 163 days in the year to the total amount of 22·250 ins., being 1·872 in. less than the average for the 65 years 1841-1905. The driest month was September with 0·623 in.; the actually wettest was October with 3·252 ins., but the relatively wettest was April with 3·139 ins. The greatest fall in one day was 1·026 in. on June 29, the exact anniversary of the wettest day in 1906. Falls of more than half an inch occurred also on April 26, June 1, November 18, 26, and 27, December 12 and 13. An exceptionally long period without rain was one of nineteen days from September 7 to September 25 inclusive.

The greatest recorded pressure of the wind was 23·0 lbs. to the square foot on March 19. On five other days pressures exceeding 20 lbs. to the square foot were recorded. The greatest daily velocity was 936 miles on February 20, and the least 22 miles on September 12. The greatest hourly velocity was 50 miles for the hour ending at noon on February 20. The total movement for the year was 103,281 miles, the greatest monthly movement being 11,450 miles in December, and the least 5157 miles in September. The summer was exceptionally windy; a comparative lull in July, however, enabled 1882 to retain its "record" for the three months total, though June 1907 with 10,606 miles was easily the windiest June in the Greenwich records, beating 1882 by 867 miles. The mileage for the three summer months was 27,025, as against 28,117 in 1882.

A discussion of 40 years' homogeneous records of the Robinson anemometer is in progress, but changes in the staff have greatly hindered it, the only portion actually adopted for use being the daily average, for which, from January 1, 1907, a table constructed similarly to that in use for daily temperature has been employed.—WALTER W. BRYANT, for the Astronomer Royal, March 17, 1908.

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REPORT OF THE COUNCIL

FOR THE YEAR 1907.

[Submitted to the Annual General Meeting, January 15, 1908.]

IN presenting their Report, the Council observe with pleasure the marked and increasing interest which is being taken in the science of Meteorology throughout the country. The Lectures and Exhibitions inaugurated by the Society are bearing fruit; and that the efforts of the Society are appreciated, is shown by the large increase in the roll of the Fellows, who now exceed 700, a number which has never before been reached.

Amongst the losses by death the Council have to record the names of six Fellows who have done good service to Meteorology in various ways. Dr. Robert Barnes and Admiral John Pearse Maclear were for some time members of their body; Dr. Alexander Buchan was the first recipient of the Symons Memorial Medal; Mr. Henry Chamberlaine Russell was the Government Astronomer for New South Wales; Dr. Wilhelm von Bezold of Berlin, an Honorary Member, was the head of the Prussian Meteorological Institute; and Dr. Maurits Snellen, also an Honorary Member, was formerly the head of the Meteorological Institute of the Netherlands.

Committees.—The Council have been materially assisted during the year by the following Committees:—

EDITING COMMITTEE.—The President, Messrs. Bayard, Bentley, Inwards, and Scott.

GENERAL PURPOSES COMMITTEE.—The President, Secretaries, Treasurer, Messrs. Bentley, Inwards, Latham, and Shaw.

KITE COMMITTEE (to co-operate with other bodies for the promotion of the study of the Upper Atmosphere).—The President, Secretaries, Col. Capper, Messrs. Cave, Curtis, and Capt. Hepworth.

LOCAL SCIENTIFIC SOCIETIES COMMITTEE.—The President, Secretaries, Treasurer, Messrs. Bentley, Clark, and Druce.

Co-operation with the Meteorological Office.—The Council regret that, as concurrence on the part of all the meteorological authorities interested has not yet been secured, the Meteorological Office has not been able to carry out the scheme for a joint publication of Monthly Summaries of Observations for the British Isles. The matter is being kept in mind, and the Council trust that before long the desired end will be attained. The arrangements under which certain meteorological data are supplied by the Society to the Meteorological Office have been revised at the request of the Director.

Symons Memorial Medal.—The Council have awarded the Symons Gold Medal for 1908 to Monsieur Léon Teisserenc de Bort, in consideration of the distinguished work which he has done in connection with meteorological science, especially the study of the upper air.

Howard Medal.—The Howard Medal, which is competed for annually by the Cadets of the Nautical Training College, H.M.S. *Worcester*, was won by Cadet Dennis Duncan Philby, for an essay on "The Meteorology of the Atlantic."

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Lecture.—Major B. F. S. Baden-Powell delivered a Lecture before the Society on March 20, on "The Exploration of the Air," which was illustrated by models and lantern slides.

Kite Committee.—This Committee co-operates with a Committee of the British Association and with the Meteorological Office. The Kite work at Glossop Moor, Derbyshire, has been continued under the direction of Mr. J. E. Petavel, F.R.S., and ascents have been made when circumstances permitted. A paper embodying a discussion of the Kite observations made at the four stations in England during 1906-7 was read at the November meeting of the Society.

The Committee have learned with much pleasure that mainly through the liberality of Dr. Arthur Schuster, a Fellow of the Society, the University of Manchester has been enabled to place the station at Glossop Moor upon a satisfactory footing for two years from January 1, 1908, at an estimated cost of about £1000. The station is to be known as the Howard Estate Meteorological Station of the University of Manchester, and systematic observations of the upper air will be carried on there for the period named. The Committee have been asked and have agreed to provide a captive balloon for the Howard Estate Station, which is intended for use in calm weather. This will furnish observations of the upper air under quiet conditions, which hitherto have not been possible.

Systematic observations are also carried out by Mr. Dines, for the Meteorological Office at Pyrton Hill, Oxfordshire, by Mr. Cave at Ditcham Park, Petersfield, and by Mr. S. H. K. Salmon at Brighton. On the invitation of the International Commission of Scientific Aeronautics the Committee resolved to take part during the years 1907 and 1908 in an international scheme for the investigation of the Upper Atmosphere, by means of *ballons-sondes* carrying self-recording instruments, and of smaller balloons, the height and drift of which would be determined by angular measurements. For this purpose, in the past year the Joint-Committee, besides assisting in the maintenance of the Glossop Moor Station, arranged for special stations at Sellack, near Ross, Herefordshire, and at Dublin, with the co-operation of Captain Ley and of Professor Thrift respectively, and the Meteorological Office made provision for a series of ascents at Crinan, Argyleshire. Ascents were made on July 22 to 27, September 4, 5, and 6, and November 6, 7, and 8. The ascents have been successful, and reports summarising the results have been laid before the Society. A supply of pilot balloons, and also a cylinder of hydrogen gas, were sent out to Professor D'Albuquerque at Barbados, who made theodolite observations on the height and drift of balloons on November 6 to 8. Towards the expenses of the Committee's share of this investigation the Government Grant Committee of the Royal Society made a grant of £100, and in response to a letter to the Fellows of our Society issued by the Council, additional subscriptions of £40 : 16 : 6 have been received. The arrangements for 1908 are not yet completed, but the British Association has reappointed its Committee to co-operate with the Kite Committee, with a grant of £25. The Council gratefully acknowledge the services of the observers mentioned.

Local Scientific Societies' Committee.—In connection with the Society's scheme for diffusing a knowledge of Meteorology, Mr. Marriott has during

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the past year delivered lectures at nine centres in various parts of the country. At the Lincoln Show of the Royal Agricultural Society on June 25 to 29, a Meteorological Exhibit, including a typical Climatological Station, was arranged, and addresses were given by Mr. Marriott. In connection with this Show a well-attended Conference was held on the question of Nature Study in Schools, in which one of the subjects discussed was "that Elementary Meteorology is a desirable subject for rural education."

With reference to the Elementary Schools, the Committee have offered for competition by Elementary Teachers and others, three prizes of £5, £3, and £2, for the three best papers embodying a Nature Study Lesson on Weather and Climate, together with a synopsis of five other lessons suitable for children.

The Committee sent letters to the Board of Agriculture and Fisheries, the Royal Agricultural Society, the Highland and Agricultural Society, and a number of the Agricultural Colleges, calling attention to the bearing of Meteorology on Agriculture and Horticulture.

The President, on behalf of the Society, gave evidence before the Departmental Committee on Agricultural Education on the subject of Meteorology and Agriculture. Replies to these letters have been received and are now being considered.

The Geological Society's Centenary.—The Geological Society invited this Society to send a delegate to its Centenary Celebration on September 26 to 28, and at the request of the Council the President represented the Society on the occasion.

Franco-British Exhibition.—The Council having received an invitation to send a representative to serve on the Science Committee, nominated the President. Several Fellows of the Society are members of the sub-committee which has been appointed to arrange a Meteorological Exhibit.

Research Fund.—This fund is represented by £72 : 11 : 5 Consols. No grants have been made from it during the year, nor has it been increased by new donations.

Meetings.—With the exception of those in May and June, which were held in the Society's rooms, the Meetings took place as in former years, by the courtesy of the President and Council of the Institution of Civil Engineers, at their house in Great George Street, Westminster.

Dinner.—A successful Dinner of the Society was held at the Trocadero Restaurant, on Tuesday, June 18, at which seventy-five gentlemen, including a number of distinguished guests, were present. The Council hope that it will become an annual function, and be attended by the Fellows in increasing numbers.

Publications.—The volume of the *Quarterly Journal* for 1907 consists of 320 pages, and contains the papers read at the Meetings of the Society, with an abstract of the discussions that followed, correspondence, and numerous notices of meteorological interest. The section of "Meteorological Literature" has been continued as a special feature.

Four parts of the *Meteorological Record* have been issued during the year, bringing this publication up to December 1906.

For Continuation of Report of the Council, see page 122.

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APPENDIX

STATEMENT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

Balance from 1906			£321 3 1
Subscriptions for 1907	£865 0 0		
Do. for former years	43 0 0		
Do. paid in advance	92 0 0		
Life Compositions	308 0 0		
Entrance Fees	106 0 0		
		1414 0 0	
Meteorological Office—Copies of Returns	£98 15 3		
Do. Grant towards Inspection Expenses	25 0 0		
		123 15 3	
Dividends on Stock (including £47 : 19 : 10 from the New Premises Fund)		147 4 6	
Sale of Publications, &c.		31 3 7	
Advertisements		24 5 6	
		£2061 11 11	

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I.

FOR THE YEAR ENDING DECEMBER 31, 1907.

EXPENDITURE.

Journal, &c.—					
Quarterly Journal, Nos. 141 to 144	£162	0	6		
Illustrations	30	2	6		
Authors' Copies	15	14	6		
Meteorological Record, Nos. 101 to 104	86	6	6		
				£294	4 0
Printing, &c.—					
General Printing	£20	16	0		
Stationery	16	19	7		
Books and Bookbinding	20	8	11		
				58	4 6
Office Expenses—					
Salaries	£607	16	9		
Rent	212	0	0		
Coals, Lighting, and Insurance	15	5	6		
Casements, Furniture, and Repairs	25	19	0		
Postage	73	3	3		
Petty Expenses	9	4	5		
Refreshments at Meetings	14	5	7		
Telephone	6	10	0		
Lecture	10	10	0		
Two Howard Medals	2	8	6		
				977	3 0
Observations—					
Inspection of Stations	£60	5	0		
Observers	11	4	0		
Instruments	4	3	0		
				75	12 0
Stock—					
Purchase of £145 : 2 : 0 New South Wales 4 per cent Inscribed Stock at 108				156	15 2
				£1561	18 8
Balance—					
At Bank of England	£187	4	9		
At London and Westminster Bank—Deposit	300	0	0		
In hands of the Assistant-Secretary	12	8	6		
				499	13 3
				£2061	11 11

Examined, compared with the vouchers, and found correct,

January 8, 1908.

T. P. NEWMAN,
J. W. FORRESTER, } *Auditors.*

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APPENDIX

ASSETS AND LIABILITIES

LIABILITIES.

Subscriptions paid in advance	£92 0 0	
Rent for quarter ending December 25, 1907	53 0 0	
		£145 0 0
Excess of Assets over Liabilities		3730 19 6
		£3875 19 6

WM. MARRIOTT, *Assistant-Secretary.*

NEW PREMISES FUND,

Interest received on Investment	£47 19 10

RESEARCH FUND,

Interest received on Investment	£1 15 6

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I.—continued.

ON DECEMBER 31, 1907.

ASSETS.

Great Central Railway 4½ per cent Debenture Stock, £800 at 120	£960	0	0			
New South Wales 4 per cent Inscribed Stock, £800 at 105	840	0	0			
London & North-Western Railway Consolidated Stock, £400 at 149½	598	0	0			
London & North-Western Railway 4 per cent Preference Stock, £12 at 114	13	13	7			
Annuities, 2½ per cent, £231 : 11 : 9 at 82¼	190	9	7			
				£2602	3	2
Subscriptions unpaid, estimated at	£42	0	0			
Entrance Fees unpaid	23	0	0			
Interest due on Stock	57	13	5			
Interest on Deposit at London and Westminster Bank	8	13	0			
Meteorological Office—Weekly Returns, 1907	28	10	11			
Sale of Publications by E. Stanford, 1907	31	6	9			
				191	4	1
Furniture, Fittings, &c.	£465	16	3			
Instruments	117	2	9			
				582	19	0
Cash at Bank of England	£187	4	9			
Cash in hands of the Assistant-Secretary	12	8	6			
Deposit at London and Westminster Bank	300	0	0			
				499	13	3
				£3875	19	6

Examined, and Securities seen at the Bank of England,

January 8, 1908.

T. P. NEWMAN,
J. W. FORRESTER, } *Auditors.*

DECEMBER 31, 1907.

Amount paid to the Society's Fund towards the rent of offices at 70 Victoria Street				£47 19 10

Note.—The Society holds on account of this Fund £1443 : 7 : 9 South Australian 3½ per cent Inscribed Stock.

Examined and found correct,

January 8, 1908.

T. P. NEWMAN,
J. W. FORRESTER, } *Auditors.*

DECEMBER 31, 1907.

Cash at Bank of England				£1 15 6

Note.—The Society holds on account of this Fund £72 : 11 : 5 Consols.

Examined and found correct,

January 8, 1908.

T. P. NEWMAN,
J. W. FORRESTER, } *Auditors.*

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APPENDIX

SYMONS MEMORIAL MEDAL

Balance in hand from 1906	£31 4 11
Interest received on Investment	18 18 0
	£50 2 11

LOCAL SCIENTIFIC SOCIETIES'

Balance from 1906—		
Deposit at London and Westminster Bank	£100 0 0	
Interest on ditto	3 11 11	
Cash at Bank of England	28 16 10	
Ditto in hands of Assistant-Secretary	7 7 9	
		£139 16 6
Contributions—Capt. Hepworth		1 1 0
,, Mr. Mellish		5 0 0
Lectures—Fees and Expenses		45 17 6
		£191 15 0

KITE OBSERVATION

Balance in hand from 1906	£74 8 1
Grant from the Royal Society Government Grant Fund	100 0 0
Contribution—Anonymous Donor	25 0 0
Do. Mr. D. Buckney	1 1 0
Do. Capt. M. H. Clarke	0 10 6
Do. Mr. F. Druce	2 2 0
Do. Mrs. Lyndon	1 1 0
Do. Mr. H. Mellish	2 0 0
Do. Mr. R. W. Munro	2 2 0
Do. Mr. C. M. Powell	5 0 0
Do. Mr. J. T. Southall	2 0 0
	£215 4 7

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I.—continued.

FUND, DECEMBER 31, 1907.

Cash at Bank of England, December 31, 1907			50 2 11
			£50 2 11

Note.—The Society holds on account of this Fund £630 Cardiff Corporation Redeemable Stock, 3 per cent.

Examined and found correct,

January 8, 1908. T. P. NEWMAN, J. W. FORRESTER, } *Auditors.*

FUND, DECEMBER 31, 1907.

Lecturer's Fees and Expenses			£35 2 4
Exhibit at Royal Agricultural Society's Show			33 8 8
Lantern Slides and Diagrams			2 13 0
Instruments			0 18 11
Fillets for Frames			1 10 0
Printing, Postage, etc.			7 15 2
Advertisements *re* Prize Competition			1 11 6
			£82 19 7
Balance—			
Cash at Bank of England	£7 7 9		
Do. in hands of the Assistant-Secretary	1 7 8		
Deposit at London and Westminster Bank	100 0 0		
			108 15 5
			£191 15 0

Examined and found correct,

January 8, 1908. T. P. NEWMAN, J. W. FORRESTER, } *Auditors.*

FUND, DECEMBER 31, 1907.

Balloon Observations at Manchester			£34 4 1
Do. do. at Sellack			31 19 4
Meteorographs			6 0 0
Rewards			1 0 0
Hydrogen for Barbados Observations			5 18 4
Indiarubber Balloons			0 18 0
			£79 19 9
Cash at Bank of England, December 31, 1907			135 4 10
			£215 4 7

Examined and found correct,

January 8, 1908. T. P. NEWMAN, J. W. FORRESTER, } *Auditors.*

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Stations.—In consequence of the removal of the observers, observations have been discontinued at Market Drayton, Shropshire; Pirbright, Surrey; and Southwold, Suffolk. The Council have accepted observations from the following new Climatological stations:—Bournemouth, Hants; Brookwood and Burgh Heath, Surrey; Killerton, Devon; Midhurst, Sussex; Sandwich, Kent; and Ware, Herts.

Inspection of Stations.—Forty-six stations, chiefly in the west and south-west districts, were inspected by Mr. Marriott, and found to be on the whole in a satisfactory condition. Mr. Marriott's report will be found in Appendix II., p. 123.

Phenological Report.—This report was prepared as usual by Mr. E. Mawley, and read at the February meeting. The Society owes its best thanks to Mr. Mawley for his labours in collecting and discussing the returns from 108 stations, and for keeping in communication with so large a body of special observers during so many years.

Library and Bibliography.—As the serial publications have increased beyond the space provided for them, those books which do not bear upon meteorology have been eliminated, and the remaining serials have been rearranged on the shelves. This rearrangement necessitated the alteration of the shelf numbers on the catalogue slips, and the revision of the slip catalogue has been taken in hand. The Subject Classification adopted in 1901 having proved insufficient, the revised Subject Classification of the *International Catalogue of Scientific Literature* has been adopted with certain modifications and additions. The Catalogue is being prepared in two parts:—(1) List of titles in alphabetical order of authors and institutions, each slip bearing the subject registration number in the top right-hand corner; and (2) a subject catalogue, each sub-section containing the titles of all works relating to that registration number in the subject catalogue. Up to the end of the year 5461 authors' slips and 6299 subject slips have been dealt with. The additions to the Library will be found in Appendix V., p. 139. During the year 4649 cards have been prepared for the Society's Bibliography; and 256 authors' slips and 411 subject slips of titles of works bearing on Meteorology, published in the British Isles, have been made for the *International Catalogue of Scientific Literature.* The Council have to express their recognition of the courtesy of the Editor of the *Geographical Journal* for supplying advance proofs of the monthly Bibliography prepared for that publication.

Office Staff.—The Council have found it necessary to engage an additional junior assistant, and they trust that with this help the staff can carry on the work of the office with its wonted efficiency. The work and usefulness of the Society have during recent years increased in many directions, and the Council recognise the efforts made on the part of the staff to cope with it.

Offices.—As the noise of motor and other traffic in Victoria Street has increased to such an extent as to interfere with work, the Council have directed that double windows be fitted in the rooms facing the street.

Fellows.—The changes in the number of Fellows are given in the following table:—

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Fellows.	Annual.	Life.	Honorary.	Total.
1906, December 31	500	149	20	669
Since elected . . .	+ 120	+ 9	...	+ 129
Since compounded .	− 5	+ 5	...	0
Reinstated	+ 1	...	...	+ 1
Deceased	− 13	− 4	− 2	− 19
Retired	− 23	...	...	− 23
Removed from List .	− 16	...	...	− 16
Lapsed	− 9	...	...	− 9
1907, December 31	555	159	18	732

Deaths.—The Council regret to have to record the loss by death of two Honorary Members and seventeen Fellows.

Samuel Barker, M.D.	elected	Nov.	21, 1866.
Robert Barnes, M.D., F.L.S.	„	Apr.	20, 1887.
Professor Wilhelm von Bezold (Hon. Member)	„	May	18, 1892.
John Howard Worthington Biggs	„	Nov.	19, 1902.
Joseph Broome, J.P.	„	Dec.	18, 1896.
Alexander Buchan, M.A., LL.D., F.R.S. (Symons Medallist)	„	Dec.	17, 1902.
Patrick Doyle, F.G.S.	„	Dec.	18, 1878.
John Farrah, F.L.S.	„	Apr.	18, 1894.
Joseph Groves, B.A., M.D., F.G.S.	„	Jan.	18, 1888.
Admiral John Pearse Maclear, F.R.G.S.	„	Feb.	16, 1881.
Thomas Henry Goodwin Newton, M.A.	„	Nov.	17, 1880.
William Oelrichs	„	May	18, 1881.
John Montague Phillpott	„	Dec.	20, 1905.
John Byrne Power, M.R.C.P.I., D.P.H.	„	Dec.	18, 1901.
Simpson Rostron, J.P.	„	Feb.	18, 1880.
Henry Chamberlaine Russell, B.A., C.M.G., F.R.S.	„	Nov.	18, 1874.
Dr. Maurits Snellen (Hon. Member)	„	Jan.	17, 1894.
Lieut.-Gen. John Sprot	„	Dec.	20, 1899.
Lawrence Charles Hills Young	„	May	16, 1906.

APPENDIX II.

INSPECTION OF STATIONS, 1907.

All the western and south-western stations have been inspected, and were found to be in a generally satisfactory condition. The number of thermometers tested has been 220, in 21 of which changes of zero had occurred. One rain-measuring glass was found to be defective.

At two stations the whole of the bulb of the wet thermometer was thickly covered with an incrustation of lime. I have occasionally seen a slight deposit on the bulbs at other stations, but never anything like that on these two

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thermometers. On comparing these instruments in water along with the other thermometers, I was greatly puzzled to find that they were reading 0°·5 and 0°·8 too low respectively. On the first occasion I was not able to remove the incrustation. On the second occasion, however, I succeeded, by scraping it with a penknife and by means of sulphuric acid, to completely remove it, when the thermometer resumed its proper reading. I am at a loss to account for the fact that the thermometer read too low owing to the incrustation round the bulb, but it points very strongly to the urgent necessity of every observer taking care to see that his wet bulb thermometer is kept perfectly clean and in good condition.

I occasionally experience some difficulty with the Phillips' maximum thermometer, as it is apt to read higher when hung horizontally than when held vertically. In some instruments the detached portion of mercury forming the index may run up the tube to the extent of fully 1° or more. It would be an advantage if the instrument makers would arrange for the air speck not to expand unduly, and so force the detached portion of mercury farther along the tube than to the position indicating the actual temperature at the time.

WM. MARRIOTT.

October 15, 1907.

NOTES ON THE STATIONS.

ABERYSTWITH, *July* 16.—The thermometers, etc., were, as before, in a small railed-off enclosure in the Castle grounds. A larger enclosure was authorised by the Corporation some time ago, but it has not been carried out. The rainfall record must be too small. That recorded in Dr. Thomas's garden in the North Parade is more nearly representative of Aberystwith. A Campbell-Stokes recorder was set up at the beginning of last year. The ball was not in the centre of the frame, being too high. A church tower on the east-south-east makes an angle of 7½° and the old Castle on the south-south-east an angle of 15°. As the cards in the sunshine recorder were liable to shift in strong winds, I recommended that they be held in the frame by clips. The vernier of the barometer had a tendency to slip down.

ARDGILLAN, *July* 20.—This station was in good order. Captain Taylor has an interesting set of earth thermometers, ranging from 1 to 12 feet. I tested altogether seventeen thermometers.

ASHBURTON, *September* 2.—On comparing the thermometers it was found that the dry bulb had gone up 0°·2. The maximum thermometer, when placed horizontally, read 1° higher than when placed vertically; so it has been considered desirable to make a supplementary correction for that amount. Mr. P. F. S. Amery died July 27. His brother, Mr. J. S. Amery, is continuing the observations.

BATH, *August* 13.—I suggested that the legs of the thermometer screen should be strengthened in order to prevent shaking in windy weather. The water receptacle for the wet bulb was imbedded in an outer receptacle which was filled with stearine wax, in order to prevent the water freezing in winter time. The outside of the glass bottle in the 8 a.m. rain gauge was also covered with stearine wax. As the large hotel on the east of the Guildhall cut off some of the morning sun, a new Campbell-Stokes recorder was obtained and mounted on the top of a lamp-post at the Alexandra Park, which is at the summit of a hill on the south of Bath, about 500 feet above sea-level. The exposure is free and open. The ball was not quite in the centre of the frame, being too high.

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On comparing the thermometers, it was found that the 4-feet earth read 0°·8 too high.

BELMONT, *August* 20.—The grass minimum thermometer was out of order owing to the column of spirit being much broken up. This I set right. I recommended that some trees near the rain gauge should be topped. The station was otherwise in good order.

BLACKPOOL, *July* 30.—On measuring the chain and tube of the earth thermometer, I found that the bulb was at a depth of 3 feet instead of 4 feet. The top of the tube was 1 foot above the ground. I recommended that at the end of the year the tube should be driven down to 4 feet. The frame of the sunshine recorder was not quite level. Apparently the wooden structure on which it is mounted had warped owing to weather changes. The thermometer screen required painting. Dr. Coutts has had a small embankment made outside the railed enclosure, about 2 feet high on the south-west side, in order to break the force of the wind. The anemoscope and pressure-tube anemometer appeared to be all right. The mercury in the cistern of the Fortin barometer had become dirty and needed cleaning.

CAHIR, *July* 22.—The minimum thermometer had about 1°·5 of spirit up the tube. The instruments otherwise were in good condition. The observations are now taken by the gardener.

CASTLE HILL, FILLEIGH, *August* 24.—A Fortin barometer has been obtained since my last visit. The Glaisher rain gauge has a shallow funnel. I recommended that four holes be made in the inverted flange round the gauge, in order to drain off the water and so prevent its insplashing when the funnel was taken off.

CHELTENHAM, *August* 16.—The enclosure for the instruments has been made much larger, and light railings substituted for the thick high railings. On comparing the thermometers it was found that the minimum had gone up 1°·0. The grass minimum had a little spirit up the tube. A Campbell-Stokes sunshine recorder had recently been obtained, and it is placed on the summit of the dome of the pavilion in the Pitville Gardens. The ball was not quite in the centre of the frame, but this I adjusted. The rain-measuring glass was not correct, and I recommended that a new one be obtained forthwith.

CHESTER, *July* 25.—At the beginning of the year the Rev. J. C. Mitchell handed over his instruments to the Chester Corporation in order to secure the continuance of the observations. It was the intention to have the instruments placed in the Grosvenor Park, but difficulties arose which prevented this being carried out. Failing any other suitable site, Mr. Mitchell ultimately had the instruments put up at the Sewage Purification Works. The site is exceptional, being on the ground between two large concrete tanks. The conditions are therefore hardly natural. The only other suitable site close by is on lower ground ; but this is a few feet below high-water mark, and so might be flooded at times. The observations are taken by Mr. Scouller. I gave him instructions in the method of observing. The grass minimum had a considerable amount of spirit up the tube.

CULLOMPTON, *September* 4.—There was no change in the thermometers. The grass minimum had a little spirit up the tube. The sunshine recorder appeared to be in adjustment. As some trees have grown up in a neighbouring garden, and might possibly slightly affect the winter sunshine in the morning and evening, I recommended that they be topped, if permissible.

DUBLIN, *July* 19.—The instruments were in the same position as at my last visit. On comparing the thermometers it was found that the maximum

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had gone up 0°·3. Trees on the east and north-west required cutting back. Sir John Moore is a very keen observer, and has made the best of the limited space at his disposal.

DUBLIN (TRINITY COLLEGE), *July* 19.—The thermometer screen required painting. The grass minimum had about 1°·5 of spirit at the top of the tube. The ball of the sunshine recorder was not quite in the centre of the frame, being too near the eastern side. The trees on the west evidently cut off some of the evening sun.

FALMOUTH, *August* 31.—The minimum thermometer had 1°·0 of spirit up the tube. Otherwise the instruments were all in good order.

GWERNYFED PARK [BRECON], *August* 20.—The wet bulb was not working properly, the muslin being dry and the conducting thread too thin. I explained how to keep the muslin and thread in good order. The minimum apparently had a little spirit at the top of the tube. The pipe of the rain gauge was broken off the funnel. The thermometer screen required strengthening and painting.

HAVERFORDWEST, *August* 21.—The grass minimum had some spirit up the tube. The rain gauge required a little soldering. A new Campbell-Stokes sunshine recorder had been obtained, and was in good adjustment. Birds have so frequently interfered with the ball and card that Mr. Phillips has been obliged to put a wire protection over the recorder to keep the birds off. I found that the amount of sunshine had been measured with the top of another card instead of along the actual burn.

HOYLAKE, *July* 26.—The grass minimum had a bubble of air in the column of spirit. I pointed out that the muslin on the wet bulb should fit tight round the bulb.

ILFRACOMBE, *August* 22.—On comparing the thermometers it was found that the minimum had gone up 0°·2. The pipe at the bottom of the funnel of the rain gauge had been broken off.

KILLERTON [EXETER], *September* 4.—The wet bulb had a thick incrustation of lime all round the bulb. On comparing the thermometer I found that it was 0°·8 too low. After removing the incrustation by means of sulphuric acid and by scraping it with a penknife, the thermometer resumed its proper reading. The rain gauge in use is the Crosley registering pattern, the funnel of which is 10 inches square. I recommended that a Snowdon gauge be obtained before the end of the year.

KINGSTOWN, *July* 23.—The instruments were in good condition. Since my last visit the screen has been raised so that the thermometers are now four feet above the ground, and the glass has been taken out of the door of the screen and louvering put in. I suggested that the inside of the screen should be washed and painted white. The observations are taken by Mr. Mason, the park curator, but Dr. Power takes the cloud observations. I did not test the instruments, as Mr. Lempfert was to inspect the station for the Meteorological Office in the course of a few days. The maximum and minimum thermometers are strapped up to prevent vibration in wind. [Dr. Power died a few weeks after my visit. See p. 136.]

LECHLADE, *September* 16.—Mr. Metcalfe in September 1906 removed from Roche Court, Winterslow, to Claydon House, Lechlade. The ground is flat, being in the Vale of Whitehorse; the river Thames is about half a mile to the south. The instruments are well exposed. The tube of the maximum thermometer was liable to slip down, so I wedged it up with cork. Owing to the difficulty of finding a suitable place for the Campbell-Stokes sunshine recorder, it has not been found advisable to take any records of the sunshine.

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The 1-foot earth thermometer was found to be only at the depth of nine inches, I recommended that the tube be driven three inches farther into the ground.

LLANDUDNO, *July* 24.—On comparing the thermometers it was found that the minimum had gone down 0°·2. The cylinder of the rain gauge had apparently been knocked several times when the grass was cut, and so the funnel was difficult to take off. I suggested that it be made to fit on easier. The sunshine recorder appeared to be in adjustment, but there was no sun at the time of my visit. I suggested that clips be used to keep the cards fixed, as birds occasionally peck at the ends of the cards. The young man who had been assisting with the observations for some time had recently left, so a new deputy had been taken on.

LLANERCHYMEDD, *July* 18.—The instruments were in the same position as previously. I requested that more attention be given to the wet bulb in frost, and also that the thermometers be read to tenths of a degree. On comparing the thermometers it was found that the maximum now reads 0°·1 too high, and the minimum is 0°·4 too high.

MALMESBURY, *August* 12.—The instruments were in good order. I suggested a different arrangement of the water receptacle for the wet bulb, and urged the observer to read the thermometers to tenths of a degree.

MALVERN, *August* 17.—I recommended that the maximum thermometer be hung more inclined, in order to prevent the mercury jumping up the tube when placed on the screen after being set. The legs of the thermometer screen required strengthening in order to prevent vibration in wind. I suggested that a creeping plant near the rain gauge should be cut back.

MIDHURST, *August* 8.—As it was proposed to establish a meteorological station at the King Edward VII. Sanitorium, I went down on this day and set up the instruments. They are placed on a lawn on the south of the building and have a good exposure. The height is 480 feet above sea-level.

NEWQUAY, *August* 30.—The thermometer screen required strengthening to prevent vibration in wind. The rim of the rain gauge required soldering on to the funnel. The sunshine trace was not running parallel with the card, as the ball was not in the centre of the frame of the recorder. I tried to remedy this by endeavouring to shift the pedestal, but this was not sufficient. I pointed out to Dr. Vigurs how the frame might be unscrewed and readjusted, so as to bring the ball into the centre.

NORTHWICH, *July* 26.—I recommended that the maximum thermometer be mounted a little more on the incline, to prevent the mercury running up the tube. As there is a great deal of smoke and other impurity in the air, I recommended that the thermometers be occasionally washed.

PENZANCE, *August* 29.—The thermometer screen required painting, and the rain gauge needed a little soldering. The Campbell-Stokes and the Jordan sunshine recorders seemed to be in good adjustment.

PORTHCAWL, *August* 14.—The mercury in the maximum thermometer seemed to have a tendency to run up the tube, so I recommended that it be mounted more on the incline. I urged that the muslin and cotton on the wet bulb be changed more frequently. The band of the Glaisher rain gauge had parted company at one place with the funnel, and so extra rain was liable to run into the bottle below. I recommended that it be re-soldered, and also that holes be made in the flange to drain off the water.

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PRINCETOWN, *August* 28.—On comparing the thermometers it was found that the minimum had gone down 0°·3. The barometer was not hanging quite vertically. It had been moved since the last inspection to make room for the telephone instrument. I gave the observer instructions as to the measurement of snow. A new building will shortly be erected in the Infirmary grounds, not far from the instruments.

RODEN, *July* 15.—On comparing the thermometers it was found that the dry bulb had gone up 0°·1, and the maximum 0°·2, and that the minimum had gone down 0°·3. Small apple trees had been allowed to grow up close to the thermometer screen and rain gauge. I recommended that the screen and rain gauge be moved to a more suitable and open situation. I requested that more attention be paid to the working of the wet-bulb thermometer. The board on which the Fortin barometer was suspended was not fixed at the bottom, and so was liable to get out of the perpendicular without being noticed.

ROSS, *August* 19.—The bulb of the wet thermometer was completely covered with a thick incrustation of lime. I endeavoured to remove this, but was not successful. I therefore recommended that some acid be used for the purpose, and that the thermometer should always be kept clean. The thermometer had apparently gone down 0°·5. I recommended that some trees round the rain gauge be topped.

ROUSDON, *September* 5.—This station was in good order. The ball of the sunshine recorder was not quite in the centre of the frame. This I readjusted. The trees on the estate have grown very considerably since my last visit. Some trees on the south-west and west-south-west of the sunshine recorder make an angle of 7°, and so may cut off some of the afternoon sun in the early spring and late autumn.

RUMNEY, *August* 14.—This station was in good order. The spare maximum thermometer had an air speck in the column of mercury in addition to the index speck. When held in an upright position the thermometer read low, but when placed in a horizontal position, it seemed to read high.

RUTHIN, *July* 25.—The base of the sunshine recorder required fixing in order to keep the instrument always on the meridian. The hills and trees on the east cut off the early morning sun, as they form a considerable angle.

SALCOMBE, *August* 27.—The observations are now taken by Dr. Twining, the instruments having been removed to his garden, where there is a good exposure. They are nearly 30 feet higher than at the previous station. The minimum had 1° of spirit up the tube. The water receptacle was much too close to the bulb of the wet thermometer. I recommended a readjustment of the thermometers in the screen. The ball of the sunshine recorder was not quite in the centre of the frame. This I readjusted, and explained how the sunshine should always be measured along the actual burn on the card.

SIDMOUTH, *September* 6.—The minimum thermometer had 1° of spirit up the tube. Trees on the east cut off a little of the early morning sunshine from the Jordan recorder.

SOUTHPORT, *July* 29.—Everything at this station was in good order. The numerous self-recording and other instruments are kept at a high state of efficiency. A second Campbell-Stokes sunshine recorder has been obtained, and the results agree very closely with those from the other recorder. The Jordan sunshine recorder has been discontinued.

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TEIGNMOUTH, *September* 3.—The grass minimum thermometer had recently been broken, and the new one—hollow cylinder pattern—read 0°·3 too high. A wire cage is put over the radiation thermometers to protect them from being broken by stones thrown into the enclosure. The water receptacle was too high, and so permitted the conducting thread to siphon out the water. The board on which the Fortin barometer was suspended required fixing at the bottom to prevent it being shifted out of the vertical. The Campbell-Stokes sunshine recorder is mounted on the ridge of the roof of the lifeboat house. The exposure is good. The flagstaff, however, on the west-south-west may perhaps very slightly affect the record. The ball was not quite in the centre of the frame.

TORQUAY, *September* 3.—On comparing the thermometers it was found that the maximum had gone down 0°·5. There was a considerable difference between the readings of the thermometers when placed vertically and when placed horizontally. The Campbell-Stokes sunshine recorder appeared to be in good adjustment.

TOWYN, *July* 17.—As Mr. Harries, from the Meteorological Office, had inspected this station the previous week, I did not test any thermometers except the 3-feet earth, which appeared to be all right. The ball of the sunshine recorder was not quite in the centre of the frame, being a little too forward. Dr. Lloyd has a percolation gauge with grass top.

WAKEFIELD, *March* 14.—I called to see Dr. French, as the maximum and minimum thermometers had not been working properly. I found that the air bubble of the maximum had got into the bulb, so that the instrument was acting as an ordinary thermometer. In the minimum an air bubble had got into the column of spirit. I arranged for new thermometers to be sent, which were put into position, and I explained the method of their working. I learned that owing to increased duties at the Prison it had not been possible for the observations to be taken at 9 p.m., but that they had been taken at 8 p.m.; also, there were five warders taking the observations when on duty, so efficiency was reduced. I saw Dr. Clarke, the medical officer, who agreed to speak to the Governor with regard to permission being obtained for the night warder to take the observations at 9 p.m. as formerly.

WESTON-SUPER-MARE, *August* 15.—On comparing the thermometers I found that the minimum had gone down 1°·0, and that the grass minimum read 2°·5 too low. The mercury in the maximum at low temperatures has a tendency to run up the tube a little when set. I recommended that the thermometer be hung more on the incline. The sunshine recorder appeared to be in adjustment. A church spire on the east-south-east cuts off the sun in the morning, and the church tower on the west and west-north-west cuts off a little sunshine in the evening in the summer.

WHITCHURCH, TAVISTOCK, *August* 26.—This station was in good order. On comparing the thermometers it was found that the dry had gone up 0°·1, and the 6-inch earth 0°·2.

WOOLACOMBE, *August* 23.—The tube of the maximum thermometer was loose and liable to slip down. This I fixed with some cork. The funnel of the rain-gauge required soldering. The barometer was not hanging quite perpendicularly. This I adjusted by putting a wedge at the back of the board at the top. The sunshine recorder seemed to be in good adjustment. The hills on the east-north-east make an angle of 7°, and those on the south-east an angle of 8°. I recommended that the sunshine cards should be measured to tenths of an hour.

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APPENDIX III.

OBITUARY NOTICES.

ROBERT BARNES was a son of Philip Barnes, founder of the Royal Botanical Society of London, and was born at Norwich on September 4, 1817. He came of an old Norfolk family, for many years owners of Cromer Hall, and one of his ancestors, a namesake Robert Barnes, suffered death by burning during the Marian persecution.

At the age of nine he went with his brother Philip to school at Bruges, where he remained for several years, leaving at the outbreak of the revolution which separated Belgium from the kingdom of the Netherlands in 1830. When 15 years of age he was apprenticed to Richard Griffin, founder of an association of poor-law medical officers, and surgeon to the Old Men's Hospital, Norwich.

In due course he proceeded to University College, and received the diploma of M.D. Lond. in 1848. He also studied at St. George's Hospital and, after qualification, in Paris. He was made a Fellow of the Royal College of Surgeons by election in 1883, whilst he was for many years intimately associated with the College of Physicians. In 1859 he was elected a Fellow. In 1873 he delivered the Lumleian Lectures on Convulsive Diseases of Women.

After qualifications Dr. Barnes practised for several years at Notting Hill. His taste for obstetrics was developed early. For a time he lectured on midwifery at the Hunterian School of Medicine, and he became Obstetric Surgeon to the Western General Dispensary, and, after holding other small appointments, was elected Assistant Obstetric Physician at the London Hospital, where he had the honour of succeeding Ramsbotham in the senior appointment. He transferred himself later on to St. Thomas's Hospital, and, lastly, ended his hospital career as Obstetric Physician at St. George's.

Dr. Barnes took a prominent part in the foundation of the Obstetrical Society, and in 1884, with the co-operation of his son, Dr. Fancourt Barnes, he issued a two-volume work on *Obstetric Medicine and Surgery*. He died on May 12, 1907.

He was elected a Fellow of this Society on April 20, 1887, and served on the Council from 1893 to 1897, being Vice-President in 1894-1895.

JOHANN FRIEDRICH WILHELM VON BEZOLD was born at Munich on June 21, 1837, and was admitted to the degree of Ph.D. at Göttingen in 1860. Thence he returned to Munich as a privat-docent in 1861, became extraordinary Professor of Physics in the University in 1866, and ordinary Professor at the Polytechnic in 1868. In 1878 he undertook the organisation of the Bavarian meteorological service as Director of the Central Meteorological Station. He remained in charge of this service until 1885, when he was called to Berlin as Professor of Meteorology in the University, and Director of the Meteorological Institute, which was reorganised by him. The Institute included not only the central establishment in Berlin, which formed the headquarters of the branch for dealing with the climatology and rainfall of the Prussian kingdom, but also the meteorological and magnetic observatories at Potsdam, and later the aeronautical section at Tegal.

In the course of his long and distinguished scientific career Dr. von Bezold's activity ranged over a wide field. His writings include papers on colour vision and the retina, and the dust figures of electrical discharge; but he is best known for his contributions to meteorology on the physics of the atmosphere, the aspect of the subject which he found most attractive, and to the theory of terrestrial

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magnetism. A volume of his collected papers on these subjects was published in 1906.

He died on February 17, 1907.

He was elected an Honorary Member of this Society on May 18, 1892.

JOHN HOWARD WORTHINGTON BIGGS was the son of William Biggs of Leicester. He travelled in the East and West, and collected numerous mementoes, etc. He was greatly interested in observations of rainfall and sunshine in the Lake District, where he resided for part of every year.

In 1905 he published a large coloured diagram illustrating the average weather at Bowness on Windermere, based on astronomical and meteorological data, 1883-1902; and also another diagram entitled "Holidays and Rain." This was prepared with the object of inducing visitors to the Lake district to take their holidays earlier in the year than is the present custom, so as to avoid the heavier rainfall of the late summer and autumn.

He died suddenly on June 1, 1907, aged 65 years.

He was elected a Fellow of this Society on November 19, 1902.

JOSEPH BROOME was born on May 1, 1825, at Reston Brook, near Fredsham. When sixteen years he entered the service of Messrs. Pemberton and Savage, Manchester, who were then engaged in the dyed goods trade. A little later he took a situation with Messrs. Samson and Lennox, merchants and shippers, and eventually was admitted a partner of that firm.

In 1881 Mr. Broome was asked by the Manchester Chamber of Commerce, and agreed to represent at the French Treaty Inquiry the department of dyed and printed satins, twills, cambrics, and other descriptions of linings; and, in co-operation with the late Sir Henry Mitchell, the velvet trade, cords, and silk velvets. In the same year he was appointed a magistrate for Manchester, and in 1891, after he had lived a few years at Llandudno, he was nominated High Sheriff of Carnarvonshire. He served on the Manchester Board of Overseers, was a vice-president of the Manchester Athenæum, and for ten years was the president of the Graphic Art Club. He was also for some time one of the directors of the Union Bank of Manchester. In 1885 he founded the firm of Broome, Hallwork, and Foster, which still exists as Broome and Foster.

For nearly the whole of his long life Mr. Broome was an exceptionally active business man, but he always found time enough to devote to a great deal of public work. Much of it was of a kind that is not always recognised most prominently—quiet but useful movements in various directions for the betterment of all sorts of conditions of living. He was, too, associated with several important commercial organisations at Manchester. He was a director of the Royal Exchange, and nobody took a keener interest than he in the development of the Royal Botanical Gardens at Old Trafford, especially in the days when they were estimated at their highest value for the purpose of flower culture.

Mr. Broome was a real lover of flowers, and he tended his own garden in the way that can only be done by a gardener who has what amounts to an almost instinctive knowledge of flower-life. When he lived at Didsbury, and afterwards on his settlement at Llandudno, his garden was the chief source of his pleasure.

He died on January 25, 1907.

He was elected a Fellow of this Society on December 18, 1896.

ALEXANDER BUCHAN was born in Kinnesswood, Kinross, on April 11, 1829, and was educated at the Free Church Normal School in Edinburgh, then newly founded as a result of the Disruption of 1843, and afterwards at the University, where he took the degree of M.A. in 1864. From 1848 onwards he followed the profession of a teacher, for which indeed he was naturally gifted, and

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throughout his life he retained the power of imparting instruction easily and pleasantly. As a schoolmaster he filled appointments at Banchory, Blackford, and lastly at Dunkeld. But for a weakness in the throat that continued to trouble him through life he might never have relinquished the profession he had chosen.

The first scientific study which attracted the attention of Alexander Buchan appears to have been botany, and especially the study of the native plants of Scotland, though he took part in at least one of the long excursions to the Alps which Professor Balfour led through all the difficulties of continental travel at that period. The field botanist cannot but be interested in the weather, and we may assume that it was in this way that Buchan's thoughts were turned to meteorology.

The Scottish Meteorological Society was founded in 1855, and its early records give full particulars of the qualifications, appointment, and withdrawal of successive Secretaries; but, curiously enough, nothing is said in the published minutes of the retirement of Mr. A. H. Burgess, who was in office at the meeting on September 3, 1860, or the appointment of Mr. A. Buchan, who read a paper as Meteorological Secretary at the meeting of April 11, 1861. The subject was the cold weather of the previous Christmas, and this, so far as I can ascertain, was Dr. Buchan's first contribution to the literature of meteorology. It is interesting to observe that even at this early period he treated the problem in a distinctly geographical manner, and he called attention to a fact, the importance of which he often referred to afterwards, the remarkable difference in the distribution of low temperatures according to the configuration of the surrounding land surface. The paper concludes: "Thus the highest winter temperature is to be found along the west coast; the lowest in low plains at such a distance from the sea as not to be influenced by it, and in hollows enclosed by hills; and all places elevated above the immediately surrounding neighbourhood are effectually protected from the extremes of temperature."

Throughout his life Dr. Buchan always insisted on the importance of taking the character of the site of a station into account before using its record in drawing any general conclusions as to climate. It is not surprising that he became an original member of the Royal Scottish Geographical Society, and took a constant interest in its welfare.

From 1861 onwards Dr. Buchan was nearly as much the author as the editor of the *Journal of the Scottish Meteorological Society*, the "new series" of which was started in the following year. He spent much time on the discussion of barometrical observations during the early years at the Society, dealing at first with the records for Scotland, but soon passing on to consider the data for the whole world. It was the period of most rapid advance in meteorology; the principles of the synoptic weather chart, of the relation of wind direction to the isobars, and of scientific forecasts of the weather for short periods, had just been enunciated, and, thanks to the enthusiasm with which Buchan took the matter up in these early years, the name of Buys Ballot and the extension of the relation between barometric gradient and wind direction were soon thoroughly familiar in this country.

In 1867 he published his *Handy Book of Meteorology*, a second edition of which appeared in the following year. This book showed so firm a grasp of the principles of the science, and so thorough a mastery of observational detail, that it became the standard text-book in the language, and in later years many were the appeals made to the author to bring it up to date; but the increasing volume of official work and the burden of various important researches were such that the appeals had to be made in vain. In one way it is perhaps better that the book should remain as a landmark of the meteorological knowledge of forty years ago, for the time has now passed in which it might have been possible

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to adapt the frame for the picture of that day to the ampler canvas of the present. Following on the larger work an *Introductory Text-book of Meteorology* in 1871 presented no new features.

In 1869 Dr. Buchan read to the Royal Society of Edinburgh the paper by which his reputation as a leader in meteorology was established at once and for ever throughout the world. It dealt with a subject of such difficulty and complexity that only an enthusiast in the marshalling of figures could ever have attempted it with any prospect of success—no less a problem than the charting of the mean distribution of atmospheric pressure and of prevailing winds over the globe. This paper was perhaps the most fruitful, though it was far from being the most laborious piece of work which Dr. Buchan accomplished. A natural result was that on the return of the *Challenger* expedition in 1876 the vast mass of meteorological data accumulated in every part of the world was handed over to Dr. Buchan to report upon. Following the enlightened practice introduced for all the reports of that great expedition, additional data accumulated before and after the expedition were utilised, and so Dr. Buchan was able to prepare as the basis of his *Report on Atmospheric Circulation*, published in 1889, maps of the world representing the mean temperature, and also the mean barometric pressure and wind directions for every month as well as for the year. These entirely original maps went far towards forming a meteorological atlas, and when only a few years ago Dr. Buchan, in association with Dr. Herbertson, undertook the editorship of the volume on meteorology in Bartholomew's great *Physical Atlas*, the data compiled for the *Challenger* Report formed one of the most striking advances on the Berghaus *Atlas* upon which it was based.

Oceanography occupied a considerable share of Dr. Buchan's attention. At an early period he had organised observations of sea-temperature in connection with herring fisheries, and in later years he contributed a massive memoir on *Oceanic Circulation* to the *Challenger* Reports.

Climatology, that department of meteorology which is equally a department of geography, always claimed the lion's share of Dr. Buchan's attention. He worked as much with maps as with tables of figures, and it is to his patient labours that we are indebted for most of our knowledge as to the monthly distribution of pressure and temperature over the British Isles.

The relation of climate to disease occupied his attention, and was dealt with in several papers written jointly with Sir Arthur Mitchell, one of the founders of the Scottish Meteorological Society.

In 1883 two important enterprises engaged much of the time of Dr. Buchan; one of these was the establishment of the Scottish Marine Station at Granton by Sir John Murray. It was at this time that I was brought into close relations with Dr. Buchan, and in the instructions I received from him in the art of meteorological observing, I first recognised his vast experience and technical skill, and experienced that kindly helpfulness which never ceased to the end of his life.

The second enterprise was the foundation of the Observatory on the summit of Ben Nevis, and subsequently of a second Observatory at Fort William. For the remainder of his life the meteorology of Ben Nevis unquestionably held the first place in Dr. Buchan's scientific work. He took his share in the efforts to awaken public interest and secure the necessary funds to start the Observatories, and to carry them on; and he put forth more energy than was perhaps prudent from the point of view of health in the effort to persuade an indifferent Government to place the work on a permanent basis. This is not the place to revive the memory of old controversy, or to rake up old grievances, but without stirring the ashes of the old fires, it may be said that although the departmental committee appointed by the Government at the instance of Dr. Buchan and his

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colleagues failed to provide for the continuation of the work he had so much at heart, it did at least make recommendations of a kind which opened the way for great improvements in the conditions of meteorological work, and in the useful co-operation of the various meteorological agencies in the United Kingdom. The publication of the hourly observations at the two observatories and the discussion of the data filled his later years, and although comparatively little remained to be done, Dr. Buchan died before the completion of the last volume.

While Dr. Buchan was particularly associated throughout his long and active life with the scientific activity of Scotland, and of Edinburgh in particular, he was also well known in London, where he had a place on several important representative bodies. For many years he was the representative of the Royal Society of Edinburgh on the Committee, nominated for the most part by the Royal Society of London, for the administration of the Government grant of £4000 per annum for scientific research. In 1887 he was appointed a member of the Meteorological Council, the body which, on the responsibility of the Royal Society of London, directed the Meteorological Office and administered the sum set apart by Parliament for the meteorological service of the country. Dr. Buchan also frequently attended the meetings of international committees, and was personally acquainted with all the leading continental authorities in his own department.

When the Symons Memorial Gold Medal was founded, the Royal Meteorological Society made the first award to Dr. Buchan as the most eminent British meteorologist.

Dr. Buchan received the honorary degree of LL.D. from the University of Glasgow in 1887. He was elected a Fellow of the Royal Society of Edinburgh in 1869, a member of its council two years later, and he received in turn the Makdougall Brisbane and the Gunning prizes of the Society. In 1878 he became curator of the library, a post which, with the permanent membership of the council, he held until within a year or two of his death. In my mind, and in the minds of many who frequented the meetings of the Royal Society of Edinburgh, in the 'eighties and 'nineties of last century, the old rooms on the Mound will always remain most intimately associated with three notable figures —Professor P. G. Tait, for so many years the general secretary, Dr. Alexander Buchan, and Mr. James Gordon, the picturesque librarian. In connection with the Royal Society Club, Dr. Buchan shone in a sphere with which many to whom he was familiar in the streets and in his office never associated him, the purveyor of intellectual gaiety of the old Scottish type. As a host Dr. Buchan was always charming, and his breakfasts on the occasion of such meetings as those of the British Association are not to be forgotten by anyone who had the privilege of taking part in them. Mrs. Buchan amply seconded his hospitality, and the guest who came even for an hour could not fail to recognise a domestic life of singular harmony. Nor can we close these notes without a tribute to the memory of Miss Jessie Hill Buchan, the faithful niece and invaluable assistant who worked for so many years in the office with her uncle; and it is sad to remember that both wife and niece passed away before himself. He is survived by Dr. Hill Buchan, his only son.

In private life Dr. Buchan was full of surprises to those who expect to find a student of science a man of one idea. He took a deep interest in Church matters, and was an elder in Free St. George's. He revelled in poetry, especially in the old Scottish ballads, from which on suitable occasions he could produce singularly apt quotations. He was a firm and generous friend, and all his qualities were such as to enshrine him in the memory of those who knew him in the full vigour of his strenuous years as something grand and heroic cast in the mould of Browning's "Grammarian":—

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Here—here's his place, where meteors shoot, clouds form,
Lightnings are loosened,
Stars come and go! Let joy break with the storm,
Peace let the dew send!
Lofty designs must close in like effects:
Loftily lying.
Leave him—still loftier than the world suspects,
Living and dying.

[The above memoir was written by Dr. H. R. Mill, and is reprinted from the *Scottish Geographical Magazine*, 23, p. 427.—EDITORS.]

Dr. Buchan, who died on May 13, 1907, was elected a Fellow of this Society on December 17, 1902.

A portrait of Dr. Buchan was given in the *Quarterly Journal*, Vol. 28.

JOHN PEARSE MACLEAR was born in 1838 at the Royal Observatory of the Cape of Good Hope, his father, Mr. (afterwards Sir Thomas) Maclear, being at that time Astronomer-Royal there. He was privately educated, and showed a marked ability in mathematics and a strong desire to join the Navy. In 1851 he was appointed naval cadet and joined the *Castor*. He served as midshipman in the *Algiers* from 1854 to 1856 during the Crimean War, both in the Baltic and the Black Sea. He was sub-lieutenant in the *Cyclops* in the Red Sea at the time of the troubles at Jeddah in 1858; and during the China War and the taking of the Taku forts he was serving as lieutenant in the *Sphinx* from 1860 to 1862. He then qualified as gunnery-lieutenant, and was appointed 1st lieutenant to the *Octavia*, and served in her during the Abyssinian War in 1868, after which he was promoted to commander, and had a longer interval on shore, which was devoted to studies in various subjects, including languages and magnetism. This time also he made a walking tour in Norway with his lifelong friend Prof. Alexander Herschel,[1] whose sister he subsequently married (in 1878). He then eagerly seized the opportunity offered to him of joining in the "Total Eclipse" expedition organised by Prof. (afterwards Sir Norman) Lockyer to India in December 1871.

In 1872 the *Challenger* was fitted out for her famous dredging and sounding voyage round the world, and he was selected as her commander under Captain (afterwards Sir George) Nares; and throughout that expedition he took the keenest and most ardent interest in all the important work carried on by Sir Wyville Thomson and his scientific staff, he himself sharing in the work of magnetical observations. The experience gained during that memorable voyage added considerable value to his own later work in the Survey Service, to which he subsequently devoted the rest of his time as captain—first in the *Alert*, from 1879 to 1882, surveying in the Straits of Magellan and the great Barrier Reef of Australia, and, secondly, in the *Flying Fish* surveying ship in China, Korea, and the Eastern Archipelago, from 1883 to 1887.

He was then promoted to rear-admiral, and retired from active service, and took up the arduous work of compiling *Sailing Directions* under the direction of the distinguished hydrographer Admiral Sir William Wharton, doing much valuable work up to the very end of his life. He was engaged on his seventh volume of these *Sailing Directions*, which was for the waterways and great lakes of Canada, when, on July 17, 1907, sudden death overtook him at Niagara Falls.

While living in his quiet country home at Chiddingfold in Surrey he was

[1] Professor Herschel, F.R.S., passed away a month before his brother-in-law, at Slough, on June 18, 1907. Some of his contributions upon meteorological topics are contained in the *Quarterly Journal* of the Society. He attended (though then in a critical state of health) the May meeting in 1907, and his remarks on that occasion regarding the fall of a meteorite will be found in the *Quarterly Journal*, 33, p. 282.

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a close observer of meteorological occurrences, and was at all times an ardent lover of nature and a warm advocate for the protection of birds.

Admiral Maclear was elected a Fellow of this Society on February 16, 1881, and served on the Council in 1883, and from 1889 to 1898, being Vice-President in 1890-91.

JOHN MONTAGUE PHILLPOTT died on July 17, 1907, after an illness of four months, at the age of 34. He was an assistant in the office of the Royal Meteorological Society from February 1889 till October 1899, when he left, at the invitation of Mr. Symons, to assist him in the office of British Rainfall. He remained there, serving under Mr. H. S. Wallis and Dr. H. R. Mill respectively, until the time of his death.

Mr. Phillpott was quick and accurate in his computations, and rendered valuable assistance in both the offices in which he was engaged.

He was elected a Fellow of this Society on December 20, 1905.

DR. JOHN BYRNE POWER was born in Dublin in 1834, and was the eldest son of James Power, of Hazelbrook, Rathfarnham, Co. Dublin. In early life he suffered greatly from delicate health, and being at that time of independent means did not enter upon a professional career until somewhat advanced in years. At first he studied law, but his taste did not lie there, so later on he entered the medical profession. Delicate as he was, he possessed remarkable courage and devotedness, and on one occasion stayed on, as resident, in a large hospital crowded with cases of small-pox, while others left in panic.

Soon after he took out his degrees he was appointed senior physician to St. Michael's Hospital, Kingstown, where he had ample opportunities for the scientific pursuit of his profession. During his tenure of office there he carried out elaborate studies and experiments on the subject of the elimination of nitrogen compounds from the blood. His essay on this subject is a model of patient and thorough scientific work and research. In it he proved, for the first time, that the skin has very limited power to carry off these compounds—a fact which has a most important bearing on treatment in many crises of illness.

Dr. Power contributed many valuable essays on medical subjects, *e.g.* "Powers and Duties of Sanitary Inspectors," "The Climate of Kingstown and the South of England compared," "On the Public Health of Kingstown," "Is Drinking Sewage by Milch Cows a Danger to Public Health?" etc.

Of latter years—since his appointment as Medical Officer of Health at Kingstown—Dr. Power devoted himself, heart and soul, to that department, and by his careful records of temperature, winds, and rainfall, showed that the climate of Kingstown is superior in many respects to that of any of the well-known health resorts on the south coast of England.

Dr. Power was a gentleman of wide reading and high culture, an excellent musician, and had travelled extensively; he was of charming personality, genial and amiable to all, and universally beloved. He died on August 30, 1907.

He was elected a Fellow of this Society on December 18, 1901.

SIMPSON ROSTRON was born on April 24, 1833, and was the only son of Laurence Rostron, of Edenfield, Lancashire. He was called to the Bar by the Middle Temple in 1854. He was for many years special pleader on the Northern circuit. He held the Commission of the Peace for the county of Surrey. He was for nearly thirty years a director of the South Metropolitan Gas Company.

Mr. Rostron travelled a good deal in the early part of his life, and was very fond at one time of Alpine climbing. He was a member of the Alpine

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Club, and it was during some of these climbs that he began to make observations on the differences in temperatures, etc. He was keenly interested in extremes of heat and cold and their effects. Even up to the end of his life he would always look at the thermometers in the screen twice, if not more, in the day, and if he could not go out, would invariably ask for the weather-book. His excellent memory was most useful in remembering "record" temperatures, etc.

He was the Royal Meteorological Society's observer at Beddington since 1881. He died on November 7, 1907.

He was elected a Fellow of this Society on February 18, 1880.

HENRY CHAMBERLAINE RUSSELL was the son of the Hon. Bourn Russell and was born at Maitland, New South Wales, on March 17, 1836. He graduated at Sydney University in 1858, and was soon after appointed assistant to the Rev. W. Scott, the first Government Astronomer for New South Wales. At the age of 25 he temporarily held this latter post after the death of Mr. Scott, until Mr. Smalley was appointed. On the death of the latter in 1870, Mr. Russell was appointed Government Astronomer, and he held that post for 35 years. He reorganised the Observatory and kept it in an efficient state. He also turned his attention to meteorology.

In 1870 there were twelve meteorological observing stations in the whole state of New South Wales, and the Government could not afford any large contribution towards an increase. Mr. Russell, however, induced the squatters and farmers to make observations of rainfall and evaporation, and, by his mechanical ingenuity, furnished the stations with the necessary apparatus with the smallest possible outlay. In 1876 he had collected all the observations of rainfall made in Australia and discussed them, with the result that he believed that there was a periodicity. In 1878 he had a large number of returns from the observing stations, and after careful analysis was enabled to commence the publication of weather charts in the newspapers. In 1887, in conjunction with Sir Charles Todd of South Australia, and Mr. Ellery of Victoria, he succeeded in establishing a system of weather forecasts.

He also designed several self-recording meteorological instruments, including an anemometer, pluviometer, thermograph, electrical barograph, etc.

Mr. Russell was a member of the Board of Technical Education, and in 1891 was made Vice-Chancellor of the University of Sydney. He was elected a Fellow of the Royal Society in 1886. He was four times President of the Royal Society of New South Wales, and was in 1888 the first President of the Australasian Association for the Advancement of Science. In 1891 he was made a Companion of the Order of St. Michael and St. George. He died on February 22, 1907, in the seventy-first year of his age.

He was elected a Fellow of this Society on November 18, 1874.

MAURITS SNELLEN was born on April 1, 1840, at Zeyst, not far from Utrecht. After visiting the gymnasium at Gouda, he entered the University of Leiden, and devoted himself to the study of mathematics and physics. As a result of this study, he obtained the degree of Doctor of Mathematics and Physics in 1865. From 1863 to 1864 he was a teacher of physics and mechanics at Leiden, then from 1864 to 1867 teacher of physics in the gymnasium at Groningen, and, lastly, from 1867 to 1873 teacher of mathematics at Delft. He then gave up teaching and entered the physical laboratory of the University of Utrecht as assistant to Prof. Buys Ballot, who at the same time occupied the position of Director of the Royal Dutch Meteorological Institute.

Dr. Snellen soon became engaged in meteorological work, especially in the magnetic branch, and so he entered upon his career as meteorologist in 1877 as

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director of the first section of the Institute. In this position he remained until 1891, when, after the death of Prof. Buys Ballot, he was appointed chief director. In 1889 he was admitted as private lecturer in meteorology at the University of Utrecht. In 1902 a reorganisation took place and he was appointed director of a newly created section for terrestrial magnetism and seismology. This new position he resigned on November 1, 1905, and then settled down at Apeldoorn, where he died on October 20, 1907, at the age of 67.

Dr. Snellen took a prominent part in the Dutch North Polar Expedition on the *Varna* in 1882-83.

He was elected an Honorary Member of this Society on January 17, 1894.

Lieut.-General John Sprot was born in March 1830. He was educated partly at a preparatory academy for Addiscombe, and partly in Germany. He joined the 83rd Regiment in 1848.

He served with his regiment in India during the Mutiny, and acted as Brigade-Major to a field-force operating in Rajputana, winning the highest praise from his superior, General Roberts. In 1860 he returned home on sick leave, and in 1867 was promoted Major. Afterwards he joined the Argyllshire Highlanders, which regiment he commanded from 1869 to 1876. In 1882 he was promoted Major-General, and in 1884 he succeeded to the family estates. In 1887 he retired from the Army with the rank of Lieutenant-General. He did work in India on roads and railways in connection with the Public Works Department.

Since his succession to his estate at Riddell, Roxburghshire, General Sprot devoted himself to the pursuits of a country gentleman, and always took the keenest interest in public affairs. He was a Deputy-Lieutenant and Justice of the Peace for the county.

In 1893 he started the interesting series of rainfall and meteorological observations which he kept up to the end. One of General Sprot's most interesting meteorological experiments was made with electric-recording anemometers fixed at various heights on a great steel flagstaff 130 ft. high, which he had erected in his grounds at Lilliesleaf.

He died on March 19, 1907, aged 77 years.

He was elected a Fellow of this Society on December 20, 1899.

Lawrence Charles Hills Young was the second son of the Rev. H. Savill Young, for some years rector of Slough. He was educated at Marlborough, and then proceeded to Exeter College, Oxford, where he took honours in Indian History. He went out to India in October 1901, and joined the staff of a large mercantile firm in Bombay. He returned to England on account of ill health in the summer of 1907, and died at Henley-on-Thames on September 8, at the age of 30.

His recreation as a boy was insect collecting and entomology, and he was a keen observer of Nature. When in Bombay he rendered valuable assistance to the Natural History Society by taking in hand the rearrangement and classification of the entomological collections.

He was elected a Fellow of this Society on May 16, 1906.

APPENDIX IV.

PURCHASES DURING THE YEAR 1907.

1. Books.

International Catalogue of Scientific Literature. Fifth Annual Issue, C. Physics. F. Meteorology.

Newman, G.—Infant Mortality. A Social Problem. 8vo. London, 1906.

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SCHARF, E.—Der Hagel. 8vo. Halle-a.-S., 1906.

WALDO, F.—Elementary Meteorology for High Schools and Colleges. New York, 1896.

WASHINGTON, ENGINEER DEPARTMENT, U.S. ARMY.—Report upon United States Geographical Surveys west of the One Hundredth Meridian, Vol. 2.—Astronomy and Barometric Hypsometry. 4to. Washington, 1877.

2. PHOTOGRAPHS.

Photos of large Hailstones at Charlestown, Natal (4).

APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1907.

1. BOOKS AND PAMPHLETS.

Presented by Societies, Institutions, etc.

AACHEN, METEOROLOGISCHES OBSERVATORIUM.—Deutsches meteorologisches Jahrbuch, Aachen, 1905.—Die wolkenbruchartigen Regenfälle im Rur- und Erstgebiete am 7., 10., 17. Juni und 5. Juli 1905.

BANGALORE, CENTRAL OBSERVATORY.—Meteorology in Mysore, 1906.—Report on the Rainfall Registration in Mysore, 1906.

BARBADOS, COLONIAL SECRETARY'S OFFICE.—Returns of Rainfall in Barbados, 1907.

BARCELONA, OBSERVATORIO BELLOCH.—Hojas Meteorológicas, 1904.

BATAVIA, MAGNETICAL AND METEOROLOGICAL OBSERVATORY.—Observations, 1905, Appendices 1-3.—Rainfall in the East Indian Archipelago, 1905.

BELGRADE, OBSERVATOIRE CENTRAL.—Bulletin Mensuel, 1 and 2.

BERLIN, DEUTSCHE METEOROLOGISCHE GESELLSCHAFT.—Meteorologische Zeitschrift, Dec. 1906 to Nov. 1907.

BERLIN, GESELLSCHAFT FÜR ERDKUNDE.—Zeitschrift, 1906, No. 10, to 1907, No. 9.

BERLIN, KÖNIGLICH-PREUSSISCHES METEOROLOGISCHES INSTITUT.—Bericht über die Tätigkeit, 1906.—Deutsches meteorologisches Jahrbuch, 1905-6, Preussen und benachbarte Staaten.—Ergebnisse der Beobachtungen an den Stationen II. und III. Ordnung, 1901.—Ergebnisse der Gewitter-Beobachtungen, 1901-2.—Ergebnisse der magnetischen Beobachtungen in Potsdam, 1902.—Ergebnisse der meteorologischen Beobachtungen in Potsdam, 1903.—Ergebnisse der Niederschlags-Beobachtungen, 1903-4.—Internationaler meteorologischer Kodex. Im Auftrage des Internationalen meteorologischen Komitees, bearbeitet von G. Hellmann und H. H. Hildebrandsson.

BIRMINGHAM AND MIDLAND INSTITUTE.—Records of Meteorological Observations taken at the Observatory, Edgbaston, 1906.

BREMEN, METEOROLOGISCHE STATION.—Deutsches meteorologisches Jahrbuch, 1906.

BRISBANE, GENERAL REGISTER OFFICE.—Vital statistics, 1905.

BRISBANE, ROYAL GEOGRAPHICAL SOCIETY OF AUSTRALIA, QUEENSLAND.—Queensland Geographical Journal, 22.

BRITISH NEW GUINEA, COLONIAL SECRETARY'S OFFICE.—Annual Report for the year ending June 30, 1906.

BRUSSELS, ACADÉMIE ROYALE DE BELGIQUE.—Annuaire, 1907.—Bulletin de la classe des sciences, 1906, No. 10, to 1907, No. 8.

BRUSSELS, CONGRÈS INTERNATIONAL POUR L'ÉTUDE DES RÉGIONS POLAIRES.—Rapport d'ensemble. Documents préliminaires et compte rendu des séances, Sept. 7-11, 1906.

BRUSSELS, OBSERVATOIRE ROYAL.—Annales, Nouvelle Série, Astronomique, 9.—Physique du globe, 3.—Annuaire astronomique, 1907.—Annuaire météorologique, 1907.—Les observatoires astronomiques et les astronomes.

BRUSSELS, SERVICE MÉTÉOROLOGIQUE DE BELGIQUE.—La foudre et les arbres. Étude sur les foudroiements d'arbres constatés en Belgique pendant les années 1884-1906. Par E. Vanderlinden.

BUCHAREST, INSTITUT MÉTÉOROLOGIQUE DE ROUMANIE.—Analele, 1902.—Buletinul Lunar al Observatiunilor Meteorologice din România, 1905.—Climatologia Bucuresteana, 1902-3.—Materiale pentru Climatologia Românièi, 1905.—Meteorologia si Metrologia în România dr S. C. Hepites.—Starea udometrică si agricolă a Românièi, Nos. 27-43.

BUDAPEST, K. UNG. REICHSANSTALT FÜR METEOROLOGIE UND ERDMAGNETISMUS.—Jahrbuch 1904, Teil 4; 1905, Teile 1 and 3.

BUITENZORG, INSTITUT BOTANIQUE DE L'ÉTAT.—Observations météorologiques, 1905-6.

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CAIRO, SOCIÉTÉ KHÉDIVIALE DE GÉOGRAPHIE.—Bulletin, 6, Nos. 10 to 12.

CAIRO, SURVEY DEPARTMENT, PUBLIC WORKS DEPARTMENT.—Meteorological Report, 1904, part 1.—The Climate of Abbassia near Cairo, by B. E. F. Keeling.—The Rains of the Nile Basin in 1906, by Capt. H. G. Lyons.

CALCUTTA, METEOROLOGICAL OFFICE.—Indian Daily Weather Charts, Dec. 1, 1906, to Nov. 30, 1907.—Indian Monthly Weather Review, May to Dec. 1906.—Indian Meteorological Memoirs, 18, parts 1 and 3.—Memorandum on the Meteorological conditions prevailing in the Indian Monsoon Region before the advance of the South-west Monsoon of 1907, with an estimate of the probable Distribution of the Monsoon Rainfall, 1907.—Memorandum on the Meteorological conditions prevailing in the Indian Monsoon Region during the first half of the South-west Monsoon Period of 1907 with anticipations regarding the Monsoon Rainfall during Aug. and Sept. 1907.—Rainfall of India, 1905.—Report on the Administration, 1906-7.

CAPE TOWN, SOUTH AFRICAN PHILOSOPHICAL SOCIETY.—Transactions, 16, parts 4-5; 17, parts 1-3; 18, part 1.

CARLSRUHE, CENTRALBUREAU FÜR METEOROLOGIE UND HYDROGRAPHIE IM GROSSHERZOGTUM BADEN.—Jahrbuch, 1906.—Niederschlags-Beobachtungen der meteorologischen Stationen im Grossherzogtum Baden, 1906, part 2; 1907, part 1.

CHICAGO, GEOGRAPHIC SOCIETY.—Lantern Slide Illustrations for teaching of Meteorology.

CHRISTIANIA, NORWEGISCHES METEOROLOGISCHES INSTITUT.—Jahrbuch, 1906.—Nedböriagttagelser i Norge, 1906.

CHRIST'S HOSPITAL, NATURAL HISTORY SOCIETY.—Annual Report, 1906.

COLORADO, COLLEGE OBSERVATORY.—Annual Meteorological Summary, 1906.

COPENHAGEN, DANSK METEOROLOGISK INSTITUT.—Bulletin météorologique du Nord, Nov. 1906 to Oct. 1907.—Nautisk-Meteorologisk Aarbog, 1906.—Meteorologisk Aarbog, 1903, part 2; 1904, parts 1 and 2; 1905, part 1; 1906, part 1.—Annales de l'observatoire magnétique de Copenhague.

CORDOBA, OFICINA METEOROLÓGICA ARGENTINA.—Carta del Tiempo, Nov. 1906 to Oct. 1907.

CORNWALL COUNTY COUNCIL, SANITARY COMMITTEE.—Monthly Report, Dec. 1906 to Nov. 1907.

CRACOW, K. K. STERNWARTE.—Meteorologische Beobachtungen, Dec. 1906 to Sept. 1907.

CROYDON, NATURAL HISTORY AND SCIENTIFIC SOCIETY.—Daily Rainfall in the Croydon District, Dec. 1906 to Oct. 1907.—Report of the Meteorological Sub-Committee, 1906.

DAVOS PLATZ, KURVEREIN.—Davoser Wetterkarte, Nov. 1906 to Oct. 1907.

DUBLIN, ROYAL DUBLIN SOCIETY.—Economic Proceedings, 1, parts 9 to 11.—Scientific Proceedings, 11, parts 13 to 20.—Transactions, 11, Nos. 4 to 6.

DUBLIN, ROYAL IRISH ACADEMY.—Proceedings, 26 A., part 2; 27 A., parts 1 and 2.

EALING, SCIENTIFIC AND MICROSCOPICAL SOCIETY.—Report and Transactions, 1906-7.

EDINBURGH, GENERAL REGISTER OFFICE.—Quarterly Returns of the Births, Marriages, and Deaths registered in Scotland, for the year ending Sept. 30, 1907.

EDINBURGH, ROYAL OBSERVATORY.—Annals, 2.

EDINBURGH, ROYAL SCOTTISH GEOGRAPHICAL SOCIETY.—Scottish Geographical Magazine, 1907.

EDINBURGH, ROYAL SOCIETY.—Proceedings, 26, No. 6 to 27, No. 5.

EDINBURGH, SCOTTISH METEOROLOGICAL SOCIETY.—Journal, Third Series, No. 24.

FIUME, I. R. ACCADEMIA DI MARINA.—Meteorological Observations, Dec. 1906 and Jan. 1907.

GENEVA, SOCIÉTÉ DE GÉOGRAPHIE.—Le Globe, 46.

GENEVA, SOCIÉTÉ GENEVOISE POUR LA CONSTRUCTION D'INSTRUMENTS DE PHYSIQUE ET DE MÉCANIQUE.—Illustrated Price List of Physical and Mechanical Instruments.

GLASGOW, ROYAL PHILOSOPHICAL SOCIETY.—Proceedings, 1905-1906.

GREENWICH, ROYAL OBSERVATORY.—Magnetical and Meteorological Observations, 1905.—Report of the Astronomer-Royal to the Board of Visitors, June 8, 1907.

HALIFAX, NOVA SCOTIAN INSTITUTE OF SCIENCE.—Proceedings and Transactions, 11, part 2.

HAMBURG, DEUTSCHE SEEWARTE.—Annalen der Hydrographie und maritimen Meteorologie, 1907.—Aus dem Archiv, 29, No. 2.—Deutsche überseeische meteorologische Beobachtungen, Heft 14.—Ergebnisse der meteorologischen Beobachtungen, 1905.—Jahresbericht, 1906.—VII. Nachtrag zum Katalog der Bibliothek.—Registrierballonaufstiege in Hamburg vom April 1905 bis Marz 1906, von Dr. Paul Perlewitz.—Wetterbericht, 1907.

HONG-KONG, OBSERVATORY.—China Coast Meteorological Register, 1906.—Extract of Meteorological Observations, Nov. 1906 to Oct. 1907.—Observations, 1906.—Report

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of Committee to inquire whether earlier Warning of the Typhoon of Sept. 18, 1906, could have been given to shipping.

JAMAICA, GOVERNMENT METEOROLOGIST.—Weather Report, Sept. 1906 to Aug. 1907.

JERSEY, OBSERVATOIRE ST.-LOUIS. — Bulletin des observations magnétiques et météorologiques, 1906.

KIEFF, OBSERVATOIRE MÉTÉOROLOGIQUE DE L'UNIVERSITÉ.—Observations, 1905.

LEON, OBSERVATORIO METEOROLÓGICO.— Boletin mensual, Oct. 1906 to Nov. 1907.

LISBON, OBSERVATORIO DO INFANTE D. LUIZ.—Boletim meteorologico, 1907.—Annaes, 1904, 1905.—Observações dos postos meteorologicos, 1889, 1890 (supplements), 1904 and 1905.

LISBON, SOCIEDADE DE GEOGRAPHIA.—Boletim, **25**, Nos. 1 to 10.

LIVERPOOL, LITERARY AND PHILOSOPHICAL SOCIETY.—Proceedings, 1905-7.

LONDON, ADMIRALTY HYDROGRAPHIC DEPARTMENT.—List of Oceanic Depths received at the Admiralty during the year 1906.

LONDON, AERONAUTICAL SOCIETY.—Aeronautical Journal, 1907.

LONDON, BOARD OF AGRICULTURE AND FISHERIES.—Agricultural Statistics, 1906, Journal, **14**, Nos. 1-8.

LONDON, BRITISH ASSOCIATION.—Report, 1906.

LONDON, BRITISH BALNEOLOGICAL AND CLIMATOLOGICAL SOCIETY.—The Journal of Balneology and Climatology, 1907.

LONDON, GENERAL REGISTER OFFICE.—Quarterly Returns of Marriages, Births, and Deaths for the year ending Sept. 30, 1907.—Weekly Returns of Births and Deaths, 1907.

LONDON, GEOLOGICAL SOCIETY.—Quarterly Journal, 1907.—Geological Literature, 1907.

LONDON, INDIA OFFICE.—Schlich's Manual of Forestry, 3 ed. **1**.

LONDON, INSTITUTION OF ELECTRICAL ENGINEERS.—Journal, Nos. 181 to 186.

LONDON, INSTITUTE OF SANITARY ENGINEERS.—Journal, **9**, parts 1 and 2.

LONDON, METEOROLOGICAL OFFICE.—Daily Weather Reports, 1907.—Hourly Readings at the four Observatories in connexion with the Meteorological Office, 1905-6.—Meteorological Observations at Stations of the Second Order, 1902.—Monthly Meteorological Charts of the Indian Ocean North of 15° S. Lat. and Red Sea, 1907.—Monthly Meteorological Charts of the North Atlantic and the Mediterranean, 1907.—Report of the Meteorological Committee for the year ending March 31, 1907.—Weekly Weather Reports, 1907.—Ceylon Administration Reports, 1905; Meteorology.—Hints to Meteorological Observers in Tropical Africa.—Annual Report of the Department of Agriculture of the Province of Saskatchewan, 1905.—Southern Rhodesia, Report on Meteorology for the year ended March 31, 1903.

LONDON, METROPOLITAN WATER BOARD.—4th Report.

LONDON, OPTICAL SOCIETY.—Transactions, 1899-1905.

LONDON, NATIONAL PHYSICAL LABORATORY.—Report of the Observatory Department, 1906.

LONDON, PHYSICAL SOCIETY.—Proceedings, Nos. 120 to 122.

LONDON, ROYAL AGRICULTURAL SOCIETY.—Journal, 1906.

LONDON, ROYAL ASTRONOMICAL SOCIETY.—Monthly Notices, 1907.

LONDON, ROYAL BOTANIC SOCIETY.—Quarterly Record, Dec. 1906 to Sept. 1907.

LONDON, ROYAL GEOGRAPHICAL SOCIETY.—Geographical Journal, 1907.

LONDON, ROYAL HORTICULTURAL SOCIETY.—Journal, **32**.

LONDON, ROYAL SANITARY INSTITUTE.—Journal, **27**, No. 12, to **28**, No. 11.

LONDON, ROYAL SOCIETY.—Proceedings, Nos. 526 to 539.

LONDON, ROYAL STATISTICAL SOCIETY.—Quarterly Journal, Dec. 1906 to Sept. 1907.

LONDON, SOCIETY OF ARTS.—Journal, 1907.

MADRID, INSTITUTO CENTRAL METEOROLÓGICO.—Boletin, 1907.

MADRID, OBSERVATORIO.—Anuario, 1907.

MADRID, SOCIEDAD GEOGRAPHICA.—Boletin, **48**, No. 4, to **49**, No. 3.—Revista de geografia colonial y mercantil publicada por la sección de geografia comercial, Actas de las sesiones celebradas por la sociedad por la junta directiva y por las secciones **3**, No. 16 to **4**, No. 11.

MANCHESTER, GODLEE OBSERVATORY.—Report, 1906.

MANCHESTER, LITERARY AND PHILOSOPHICAL SOCIETY.—Memoirs and Proceedings, **51**, Nos. 1-3.

MANILA, PHILIPPINE WEATHER BUREAU.—Philippine Weather Review, May 1906 to Jan. 1907.—Report of the Director, 1904, part 3, 1905, parts 1 and 2.—The Rainfall of the Philippines, by Rev. M. S. Maso.

MARLBOROUGH COLLEGE, NATURAL HISTORY SOCIETY.—Report, 1906.

MARSEILLES, COMMISSION DE MÉTÉOROLOGIE DU DÉPARTEMENT DES BOUCHES-DU-RHÔNE.—Bulletin annuel, 1905.

MAURITIUS, ROYAL ALFRED OBSERVATORY.—Annual Report of the Director, 1906.—Results of Magnetical and Meteorological Observations, 1905.

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MERZIFUN, ANATOLIA COLLEGE.—Meteorological Records, 1906.

MESSINA, OSSERVATORIO.—Annuario, 1906.

MEXICO, OBSERVATORIO METEOROLÓGICO-MAGNÉTICO CENTRAL.—Boletin mensual, Nov. 1902 to April 1903, July-Sept. 1904.—El servicio meteorológico de la República Mexicana.—Tiempo probable durante el mes Sept. y Oct. 1907.

MEXICO, SOCIEDAD CIENTÍFICA "ANTONIO ALZATE."—Memorias y revista, **22**, Nos. 9-12; **23**, Nos. 5-12; **24**, Nos. 1-12; **25**, No. 1.

MILAN, R. OSSERVATORIO ASTRONOMICO DI BRERA.—Osservazioni meteorologiche, 1906.

MOSCOW, SOCIÉTÉ IMPÉRIALE DES NATURALISTES.—Bulletin, 1905, No. 4, 1906, Nos. 1 to 4.

MUNICH, METEOROLOGISCHE STATIONEN IM KÖNIGREICH BAYERN.—Deutsches meteorologisches Jahrbuch, Bayern, 1893-1898, Heft 5; 1899 to 1903.

NATAL OBSERVATORY.—Report of the Government Astronomer, 1906.

NEW YORK, CENTRAL PARK OBSERVATORY.—Abstracts of Registers from Self-recording Instruments, Nov. 1906 to Oct. 1907.

ODESSA, OBSERVATOIRE MÉTÉOROLOGIQUE ET MAGNÉTIQUE. — Annales, 1906.—Organisation de l'étude climatérique spéciale de la Russie et problèmes de la météorologie agricole.—Revue météorologique.—Travaux du réseau météorologique du Sud-Ouest de la Russie, 1896-1899, 1903.—Travaux du réseau météorologique du Sud-Ouest de la Russie, 1886-1896.

OÑA (SPAIN), COLEGIO MÁXIMO DE LA COMPAÑÍA DE JESUS.—Observaciones meteorológicas, 1906.

OTTAWA, DEPARTMENT OF MARINE AND FISHERIES.—Toronto General Meteorological Register, 1906.

OTTAWA, GEOLOGICAL SURVEY OF CANADA.—Summary Report, 1905-6.—Annual Report, Section of Mines, 1904.

OXFORD, CLARENDON PRESS.—The Imperial Gazetteer of India. The India Empire, **1**, Descriptive.

PAISLEY, PHILOSOPHICAL INSTITUTION. COATS OBSERVATORY.—Meteorological Observations, 1906.

PARIS, BUREAU CENTRAL MÉTÉOROLOGIQUE DE FRANCE.—Annales, 1904, II., III.—Bulletin international, 1907.—Bulletin mensuel, Oct. 1906 to Oct. 1907.—Rapport de la conférence météorologique internationale. Réunion d'Innsbruck, 1905.

PARIS, OBSERVATOIRE MUNICIPAL.—Annales, tome **5-6**.

PARIS, SOCIÉTÉ MÉTÉOROLOGIQUE DE FRANCE.—Annuaire, Nov. 1906 to Oct. 1907.

PERPIGNAN, OBSERVATOIRE.—Bulletin météorologique annuel du Département des Pyrénées-Orientales, 1905.

PERTH (W. A.), OBSERVATORY.—Meteorological Observations made at the Perth Observatory and other places in Western Australia, 1905.

PHILADELPHIA, AMERICAN PHILOSOPHICAL SOCIETY.—Proceedings, Nos. 184 to 186.—Record of the Celebration of the Two Hundredth Anniversary of the birth of Benjamin Franklin.

POLA, K.-K. HYDROGRAPHISCHES AMT.—Jahrbuch der meteorologischen, erdmagnetischen und seismischen Beobachtungen, 1906.

PORT-AU-PRINCE, SOCIÉTÉ ASTRONOMIQUE ET MÉTÉOROLOGIQUE.—Bulletin annuel, 1906.—Résumés météorologiques, Oct. 1906 to May 1907.

PRAGUE, STERNWARTE.—Meteorologische und magnetische Beobachtungen, 1906.

PRETORIA, TRANSVAAL METEOROLOGICAL DEPARTMENT.—Annual Report for the year ended June 30, 1906.

RIO DE JANEIRO, MINISTERIO DA MARINHA.—Boletim des observaçoes meteorologicas, Jan. to Oct. 1906.—Boletim semestral, No. 16.

RIO DE JANEIRO, OBSERVATORIO.—Annuario, 1907.—Boletim mensal, 1906.

ROME, SOCIETÀ SISMOLOGICA ITALIANA.—Bollettino, **11**, No. 7, to **12**, No. 5.

ROME, UFFICIO CENTRALE DI METEOROLOGICA E DI GEODINAMICA.—Annali, serie seconda, 1901, part 1.—Rivista meteorico-agraria, **27**, No. 34, to **28**, No. 28.

ROTHAMSTED, LAWES AGRICULTURAL TRUST.—Plans and Summary Tables arranged for reference in the Fields, 1906.

ST. PETERSBURG, CENTRAL PHYSICAL OBSERVATORY.—Annales, 1904.—Determination of the Height of Clouds in Darkness by means of an Electric Projector, by V. V. Kuznetzov (in Russian).—La variabilité interdiurne de la pression atmosphérique principalement en Asie, par A. Woeikof.—Materials for the Meteorology of the Free Atmosphere, by E. Rosenthal (in Russian).—North-east Storms of the Black and Azof Seas, by I. Semenov (in Russian).—Storms of Lake Baikal, by G. Iakhontov (in Russian). The St. Petersburg Floods and some Characteristic Features of the Floods of 1824, 1822, and 1777, by S. Griboedov (in Russian).—Upper Clouds from Observations made at the Constantine Observatory at Pavlovsk, by I. Nadein (in Russian).—Ueber starke Regen in St. Petersburg.

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ST. PETERSBURG, OBSERVATOIRE CONSTATIN.—Étude de l'atmosphère, fasc. 2.

ST. PETERSBURG, OBSERVATOIRE MÉTÉOROLOGIQUE DE L'INSTITUT FORESTIER IMPÉRIAL.—Observations, 1905.

SALONIQUE, GYMNASE BULGARE DE GARÇONS "ST.-CYRILLE ET METHOD."—Bulletin annuaire, 1904-5.

SAN FERNANDO, INSTITUTO Y OBSERVATORIO DE MARINA.—Observaciones meteorológicas, magnéticas y séismicas, 1906.—Eclipse total de sol del 30 de Agosto de 1905.

SAN JOSÉ (COSTA RICA), SOCIEDAD NACIONAL DE AGRICULTURA.—Boletin, Nos. 9, 10.

S. PAULO, COMMISSÃO GEOGRAPHICA E GEOLOGICA.—Boletim, No. 2, Dados Climatologicos, 1903.

SOUTHPORT, FERNLEY OBSERVATORY.—Report and Results of Observations, 1906.

STOCKHOLM, K. SVENSKA VETENSKAPS AKADEMIE.—Arkiv für matematik, astronomi och fysik, Nos. 3 to 4.

STOCKHOLM, METEOROLOGISKA CENTRAL-ANSTALT.—Månadsöfversigt af väderleken i Sverige, Oct. 1906 to Nov. 1907.—Meteorologiska Iakttagelser i Sverige, 1906.

STONYHURST, COLLEGE OBSERVATORY.—Results of Meteorological and Magnetical Observations, 1906.

STRASSBURG, INTERNATIONALE KOMMISSION FÜR WISSENSCHAFTLICHE LUFTSCHIFFAHRT.—Beobachtungen mit bemannten, unbemannten Ballons und Drachen sowie auf Berg- und Wolkenstationen, May 1905 to June 1906.—Cinquième Conférence de la Commission à Milan du 30 septembre au 7 octobre 1906. Procès-verbaux des séances et mémoires.

TACUBAYA, OBSERVATORIO ASTRONÓMICO NACIONAL.—Anuario, 1907.

TIFLIS, PHYSIKALISCHES OBSERVATORIUM.—Beobachtungen, 1896 and 1898.

TOKIO, CENTRAL METEOROLOGICAL OBSERVATORY.—Annual Report, 1897, part 2—1898, part 2; 1902, part 2; 1903, part 1; 1904, part 1; 1905, part 1.—Monthly Report, Meteorological Observations in Japan, April and May 1906.

TOKIO, METEOROLOGICAL SOCIETY OF JAPAN.—Journal, Nov. 1906 to Sept. 1907.

TORONTO, METEOROLOGICAL OFFICE.—Monthly Weather Review, Sept. 1906 to July 1907.

TRIEST, I. R. OSSERVATORIO MARITTIMO.—Rapporto annuale, 1903.

TURIN, R. OSSERVATORIO ASTRONOMICO.—Osservazioni meteorologiche, 1905.

TURIN, SOCIETÀ METEOROLOGICA ITALIANIA.—Bollettino Bimensuale, **25**, No. 11, to **26**, No. 7.

UPSALA, OBSERVATOIRE MÉTÉOROLOGIQUE DE L'UNIVERSITÉ.—Bulletin Mensuel, 1906.

UTRECHT, K.-NEDERLANDSCH METEOROLOGISCH INSTITUUT.—Annuaire 1905.—Mededeelingen en verhandlingen, No. 5.—Onweders in Nederland, 1904-5.

VALPARAISO, SERVICIO METEOROLÓGICO.—Anuario, 1905.

VENEZUELA, UNIVERSIDAD CENTRAL.—Anales, 7, No. 3.

VIENNA, LANDESSTATIONEN IN BOSNIEN-HERCEGOVINA.—Ergebnisse der meteorologischen Beobachtungen im Jahre 1902-1903.

VICTORIA, DEPARTMENT OF AGRICULTURE.—Journal, 1907.

VIENNA, K.-K. CENTRALANSTALT FÜR METEOROLOGIE UND ERDMAGNETISMUS.—Beobachtungen, Dec. 1906 to Sept. 1907.—Allgemeiner Bericht und Chronik der im Jahre 1904 in Oesterreich beobachteten Erdbeben, No. 1.—Bericht über die internationale meteorologische Direktorenkonferenz in Innsbruck, September 1905.—Jahrbuch, 1904-5.

VIENNA, K.-K. HYDROGRAPHISCHEN ZENTRAL-BUREAU.—Jahrbuch, 1904.

VIENNA, OESTERRICHISCHE GESELLSCHAFT FÜR METEOROLOGIE.—Meteorologische Zeitschrift, Dec. 1906 to Nov. 1907.

WARSAW, BUREAU MÉTÉOROLOGIQUE DU MUSÉE.—Okres "dzienny" temperatury powietrza podczas nocy podbiegnnowej, by R. Mereeki.—Réseau météorologique de Varsovie, 1905.—Sur la marche annuelle de l'intensité du rayonnement solaire à Varsovie et sur la théorie des appareils employés.

WASHINGTON, CARNEGIE INSTITUTION.—Terrestrial Magnetism, **11**, part 4, to **12**, part 3.

WASHINGTON, HYDROGRAPHIC OFFICE.—Pilot Chart of the North Atlantic Ocean, 1907.—Pilot Chart of the North Pacific Ocean, 1907.

WASHINGTON, SMITHSONIAN INSTITUTION.—Excerpt papers from the Smithsonian Report, Nos. 1670-1674.

WASHINGTON, WEATHER BUREAU.—A first Report on the Relations between Climates and Crops, by C. Abbe.—Climatology of the United States, by A. J. Henry.—Monthly Weather Review, Sept. 1906 to July 1907.

WATFORD, HERTFORDSHIRE NATURAL HISTORY SOCIETY.—Transactions, **13**, parts 1-2.

WELLINGTON COLLEGE, NATURAL SCIENCE SOCIETY.—Report, 1906.

WELLINGTON (N.Z.), REGISTRAR-GENERAL'S OFFICE.—Statistics of the Colony of New Zealand, 1905.

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WESTERN AUSTRALIA, AGENT-GENERAL.—Climate and Rainfall of Western Australia, Aug. 1906 to Oct. 1907.

YURIEF (DORPAT), STATION MÉTÉOROLOGIQUE DE L'ÉCOLE REALE.—Observations, Dec. 1906.

ZI-KA-WEI OBSERVATOIRE MAGNÉTIQUE ET MÉTÉOROLOGIQUE ET SISMOLOGIQUE.—Bulletin des observations, 1904.

ZOMBA, SCIENTIFIC DEPARTMENT.—Meteorological Observations, Sept. 1906 to Aug. 1907.

ZURICH, SCHWEIZERISCHE METEOROLOGISCHE CENTRAL-ANSTALT.—Annalen, 1905.

Presented by Individuals.

ABBE, C.—Projections of the Globe appropriate for Laboratory Methods of studying the general Circulation of the Atmosphere.—The Progress of Science as illustrated by the Development of Meteorology.

AMERY, [the late] P. F. S.—Rainfall at Ashburton, Forty Years' Record.

ANGOT, (Dr.) A.—Études sur le régime pluviométrique de la Méditerranée.

ÅNGSTRÖM, K.—Méthode nouvelle pour l'étude de la radiation solaire.—Ueber die Anwendung der elektrischen Kompensationsmethode zur Bestimmung der nächtlichen Ausstrahlung.

ARCTOWSKI, H.—Variations de la vitesse du vent dues aux marées atmosphériques.

BALDWIN-WISEMAN, W. R.—Influence of Pressure and Porosity on the Motion of sub-surface Water.—On the Flow of Underground Water.

BATES, Rev. D. C.—The Climate of New Zealand.

BAXENDELL, J.—Meteorological Observations at Southport, Dec. 1906 to Nov. 1907.

BAYARD, F. C.—Annual Report, M.O.H. Surrey County Council, 1906.

BIGGS, [the late] J. W. H.—Sunshine in the English Lake District, 1906, Comparative Table.

BIRKELAND, B. J.—Neue Feuchtigkeitstafeln für das Psychrometer unter dem Gefrierpunkt.

BLADEN, W. W.—Annual Report North Staffordshire Field Club, 1906-7.

BODDAERT, D.—Misure magnetiche nei dintorni di Torino.

BOLTON, C. P.—Waterford Weather Report, 1906.

BROWN, A., and BOOBBYER, (Dr.) P.—The Meteorology of Nottingham, 1906.

CARTER, C. C.—Report of the Felsted School Scientific Society, 1906.

CASELLA & Co.—Anemometers, Air Meters, and Wind Direction Instruments.—Self-recording Instruments for Scientific Engineering and Industrial Purposes.

CLARK, J. E.—The Windrush at Biggin.

COLBORNE, H.—Annual Report, Meteorological Observations, Borough of Hastings, 1906.

COLLENNETE, A.—Rainfall of Guernsey, 1906.—Sunshine of Guernsey, 1906.

CORBETT, (Dr.) D.—Report on the Health of the Borough of Kidderminster, 1906.

CORDEIRO, F. J. B.—The Gyroscope.

COUTTS, (Dr.) F. J. H.—County Borough of Blackpool, Meteorology for the year 1906.

DALES, C.—Annual Meteorological Report for the County Borough of Bournemouth, 1906.

DIXON, C.—Results of Meteorological Observations taken at Holland House, Middlesex, Dec. 1906 to Nov. 1907 (MS.).

DOVER, J.—Totland Bay: Report of Meteorological Observations, 1906.

EDITOR.—Ciel et Terre, 1907.

EDITOR.—Daily Graphic, 1907.

EDITOR.—Electrical Review, 1907.

EDITOR.—Indian Engineering, 1907.

EDITOR.—Journal of Horticulture, 1907.

EDITOR.—Journal of Tropical Medicine and Hygiene, April 15, 1906.

EDITOR.—Nature, 1907.

EDITOR.—Observatory, 1907.

EDITOR.—Sanitary Record, 1907.

EDWARDS, C. W.—Annual Reports of the Medical Officer of Health, Borough and Port of Lowestoft, 1906.

EIFFEL, G.—Recherches expérimentales sur la résistance de l'air exécutées à la Tour Eiffel.

EKHOLM, (Dr.) N.—Die Luftdruckschwankungen und deren Beziehung zu der Temperatur der oberen Luftschichten.—Ueber die unperiodischen Luftdruckschwankungen und einige damit zusammenhängende Erscheinungen.

EREDIA, F.—Dell' influenza della catena degli Appennini sulla distribuzione della pioggia nell' Italia centrale.—Le precipitazioni acquee nella Riviera Ligure.

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EREDIA, F., and MEMMO, G.—Contributo alla climatologia di Massaua.

FOX, W. L.—Meteorological and Magnetical Tables and Reports, Falmouth Observatory, 1906.

FRASER, (Dr.) A. M.—Report on the Health of Portsmouth, 1906.

FRUH, Dr. J.—Wasserhosen auf Schweizerseen.

GAUTIER, R.—Observations météorologiques faites aux fortifications de Saint-Maurice, 1904-5.—Résumé météorologique pour Genève et le Grand St-Bernard, 1905.

GLYDE, E. E.—Tavistock Meteorological Summary, 1906.

HALL, M.—Third Report on Earthquakes in Jamaica.—The Great Earthquake of January 14, 1907.

HANDS, A.—The Protection of Buildings from Lightning.

HANN, J.—Der tägliche Gang der Temperatur in der äusseren Tropenzone.

HELLMANN, (Dr.) G.—(Obituary notice of), Wilhelm von Bezold.

HEPITES, S. C.—Les sécheresses en Roumanie.

HEPWORTH, M. W. C.—Notes on Maritime Meteorology.

HEYWOOD, H.—Meteorological Observations in the [Cardiff] Society's District, 1906.

HILDEBRANDSSON, (Dr.) H. H., and TEISSERENC DE BORT, L.—Les bases de la météorologie dynamique: historique état de nos connaissances. 3me livraison.

HILL, G. H., & SONS.—Returns of the Rainfall in the Glasgow, Manchester, Ashton, Dewsbury, Stockport, Halifax, Blackburn, Holme Reservoirs, Oldham, and Batley Waterworks Districts, 1906.

HOOKER, R. H.—Correlation of the Weather and Crops.

HORNER, D. W.—Observing and Forecasting the Weather. Meteorology without Instruments.

HUNTER, J.—Meteorological Observations at Belper, 1907.

JODRELL, Col. C.—Observations taken at Reaseheath Hall, Nantwich, 1906 (MS.).

JONES, C. E.—Water finding. The Mystery of the Divining Rod.

LANGE, G.—The River Pilcomayo from its discharge into the River Paraguay to Parallel 22° S.

LARKIN, W. W.—Borough of Scarborough Weather Report, 1906.

LE CADET, G.—Observation de l'éclipse de soleil du 14 janvier 1907. Variations corrélatives des phénomènes météorologiques à l'Observatoire de Phu-liên (Tonkin).

LOVIBOND, J. W.—An Introduction to the Study of Colour Phenomena.

MARCH, F.—Borough of Torquay, Meteorological Report, 1904-1905-1906.

MARKHAM, C. A.—Meteorological Report for Northamptonshire, Oct. 1906 to Jan. 1907.

MARSHALL, Miss C.—Rainfall in the Lake District, Dec. 1906 to Nov. 1907.

MARTIN, E. A.—Dew-Ponds.

MAWLEY, E.—Meteorological Observations at Rosebank, Berkhamsted, Dec. 5, 1906, to Dec. 4, 1907.

MELLISH, H.—Note on an apparent secular Change in the Rothamsted Drain Gauges, by E. J. Russell.—The Weather of 1906 at Hodsock Priory, Worksop.—Weather Charts and Weather Forecasts.

MERZ, A.—Beiträge zur Klimatologie und Hydrographie Mittelamerikas.

MIDGLEY, T.—Annual Report of the Museums and Meteorological Observatory, Bolton, 1906.

MILL, (Dr.) H. R.—British Rainfall, 1906.—Symons' Meteorological Magazine, 1907.

MOORE, Sir J. W.—The Climatology of Ireland in Relation to the Public Health.

MOSSMAN, R. C.—The non-instrumental Meteorology of London, 1713-1900 (MS.).

NEWBIGIN, (Dr.) M. I.—The Study of the Weather as a Branch of Nature Knowledge.—The Swiss Valais; a Study in Regional Geography.

OBCOLAGA, J. M.—La previsión del tiempo.

OTTWEILER, E.—Die Niederschlags-Verhältnisse von Deutsch-Südwestafrika.

PARNABY, J. M.—Meteorological Report for Albert Park, Middlesbrough, Dec. 1906 to Nov. 1907 (MS.).

PRESTON, A. W.—Meteorological Notes, 1906.

RAJNA, M.—Esame di una livella dieftosa e metodo per correggerne le indicazioni.—Osservazioni meteorologiche dell' annata 1905.—Sopra le dimostrazioni della formula del cagnoli relativa alla durata minima del crepuscolo.

RAWSON, Col. H. E.—Anticyclones and their Influence on South African Weather.

RIJCKVORSEL, (Dr.) van.—Konstant auftretende secundare Maxima und Minima in dem jährlichen Verlauf der meteorologischen Erscheinungen.

ROBINSON, T.—Hoylake and West Kirby Urban District Council. Meteorological Report and Results of Observations, 1906.

ROTCH, A. L.—Benjamin Franklin and the first Balloons.—Did Benjamin Franklin fly his Electrical Kite before he invented the Lightning Rod?—Results of the Franco-American Expedition to explore the Atmosphere in the Tropics.—The International Aeronautical Conference of October 1906, at Milan.

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SALLE, O.—Das Wetter, 1907.

SAXBY, A. C.—Annual Report on the Meteorology of Cheltenham, 1906.—Meteorological Report, 1907.

SCHAEFER, T. W.—The Contamination of the Air of our Cities with Sulphur dioxid the cause of Respiratory Disease.

SCOBLE, H. T.—Land Treatment of Sewage.

SHAW, (Dr.) W. N.—Climate and Health.

SNELL, E. H.—City of Coventry, Annual Report on the Health of the City, 1906.

SPANG, H. W.—A Treatise on perfect Railway Signalling.

STILWELL, H.—Returns of Rainfall, etc., in Dorset in 1906.

STOKES, J.—Annual Report of the Meteorology of Margate, 1906.

STUPART, R. F.—The Climate of Yukon Territory.

SUTTON, J. R.—A Contribution to the Study of Evaporation from Water Surfaces.—Variability of Temperature in South Africa.—The Diurnal Variation of Barometric Pressure.

SYMONS, (Dr.) W. H.—Annual Report to the Bath Urban Sanitary Authority by the Medical Officer of Health, 1906.—Meteorological Notes. Reprinted for private Circulation from the Bath Health Reports.

TYLER, W. F.—The Psycho-physical Aspect of Climate with a Theory concerning Intensities of Sensation.

WAGSTAFFE, W.—Report of the Weather, Sevenoaks, 1906.

WARRY, (Dr.) J. K.—Report on the Sanitary Condition of the Hackney District, 1905.

WATZOF, SPAS.—Bulletin sismographique de l'Institut météorologique central de Bulgarie, Nos. 1-2.—Tremblements de terre en Bulgarie, No. 7.

WESTMAN, J.—Durée et grandeur de l'insolation à Stockholm.—Mesures de l'intensité de la radiation solaire faites à Upsala en 1901.

WETHERALL, G. B.—Weather in 1906 (at Worcester).

WETHERILL, H. E.—Hygromedry.

WILLCOCKS, Sir W.—The Irrigation of Mesopotamia.

WOOD, (Dr.) G. B.—A few Medical Notes on Sandown, Isle of Wight, as a Health Resort in Winter.

WORTH, R. H.—Twenty-fourth Report (Third Series) of the Committee on the Climate of Devon.

WRAY, C.—Federated Malay States. Pahang Administration Report, 1906.

YAMASHINA, PRINCE.—Ergebnisse der meteorologischen Beobachtungen auf dem Tsukubasan, 1902.

2. PHOTOGRAPHS.

GREENWOOD, H. B.—Floods at Kendal, Nov. 2, 1898 (4).

3. LANTERN SLIDES.

LANDER, A.—Lander and Smith's Recording Instruments (11).

Large Hailstones.

A correspondent to a South African newspaper writes:—

"On the afternoon of December 1, 1907, we were visited by a terrible hail-storm in the district of Jacobsdal, the part most affected being Lower Riet river. Hail fell continuously for about 25 minutes, and some pieces weighed as much as 3½ oz., and were as large as ducks' eggs. The live-stock did not suffer very much, but the plantations are largely destroyed. On one of the farms a piece of lucerne in its prime was beaten down so that it almost resembled a field that had just been mown. Elderly people say that they have never seen the like in this district."

Hail Shooting in Italy.

Mons. A. Angot, the Director of the Bureau Central Météorologique, Paris, calls attention to a slight error on pages 25 and 26 in the last number of the *Quarterly Journal* in the Note on Hail Shooting in Italy. He says:—

"The Casa Aulagne di Monteux is not a station, but a manufacturing firm, the house of Aulagne of Monteux, which sells the fusees (rockets?) for shooting against hail, and thinks that these fusees attain the height of 1200 yards; which seems to me extremely doubtful.

"In Italy they tried, after the Greinitz cannons, the Aulagne fusees, and then Marazzi bombs."

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PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 15, 1908.

Ordinary Meeting.

Dr. HUGH ROBERT MILL, President, in the Chair.

CHARLES JOHN BARKER, Hillcroft, Russell Hill, Purley;
ELIOTT SCARLETT CURREY, M.Inst.C.E., Fachlwyd Hall, Ruthin;
Rev. RICHARD PATESHALL DANSEY, Kentchurch Rectory, Hereford;
CHARLES EDWARD JEFFERIES ESDAILE, J.P., Cothelestone House, Taunton;
MURRAY T. FOSTER, Cullompton, Devon;
ERNEST GOLD, M.A., 3 Devana Terrace, Cambridge;
Rev. GEORGE RANDOLPH HADOW, Wylye Rectory, Wilts;
JOHN ROBERT GETHIN JONES, Taly Cafn, N. Wales;
JOHN JONATHAN KERMODE, 62 Dale Street, Liverpool; and
MISS CORDELIA F. MARSHALL, Skelwith Fold, Ambleside,
were balloted for and elected Fellows of the Society.

January 15, 1908.

Annual General Meeting.

Dr. HUGH ROBERT MILL, President, in the Chair.

Mr. E. H. S. BRUCE and Mr. H. N. FFARINGTON were appointed Scrutineers of the ballot for the Council.

REPORT OF THE COUNCIL.

THE PRESIDENT remarked that as everyone had received a copy of the Report of Council, he proposed that this should be taken as read. He therefore moved that "The Report be received and adopted, and that it be printed in the *Quarterly Journal*." The Report seemed to him to be very satisfactory. The pulse of the Society was generally taken to be the number of Fellows, especially of new Fellows, as compared with the number of previous years. This year the number of Fellows was larger than ever before, and those removed from the Society for various reasons were not so numerous as usual. The Report set forth the work done during the year. He, the President, would specially refer to the work done by the Kite Committee, which concerned itself with the exploration of the upper air, and the share which the Society had taken in forwarding the national and international investigation of the atmosphere at points far above the surface. This investigation had been carried on in different parts of the British Isles, and the results had occupied a good deal of the attention of the Society at its recent Meetings.

Another Committee showing excellent work was the Local Scientific Societies' Committee, which had the object of fostering the interest of the public in meteorology and improving the position of meteorological science in this country. An interesting feature was the offer of three prizes to teachers in a competition organised by the Society, for the best school lesson on climate or weather, which had the effect of directing a quite remarkable amount of public attention to the subject. The least satisfactory item of the Report was, perhaps, the stationary state of the Research Fund. There was no increase in this Fund,

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and no draft had been made upon it; possibly it would increase more rapidly if it were more used, but its object was being carried out to a certain extent by means of other funds.

The President then referred to the very successful Dinner which had taken place last year, and was, he hoped, the first of a long series. He went on to say that the Library was unique and rapidly growing. It contained a remarkable collection of books leading back to the earliest times, while the Bibliography of Meteorology was the most extensive in the world. The Balance-sheet was favourable, showing a comfortable sum in hand. There was, he regretted to say, a long list of deaths of Fellows, and especially of Honorary Members.

Mr. F. Campbell Bayard, in seconding the Resolution, remarked that the Prize Competition organised by the Local Scientific Societies' Committee was likely to prove a great success. Already 1500 circulars respecting it had been sent out, and the Competition was attracting an immense amount of interest. He, Mr. Bayard, thought that special mention should be made of the death of Admiral Maclear, an old and valued Fellow of the Society.

The Resolution was adopted. [The Report is printed on p. 113.]

Thanks to the Council and Auditors.

Mr. A. Brewin moved: "That the thanks of the Society be given to the Council for their services during the past year, and also to the Auditors." He said that he did not think any Society in London had a more hard-working Council. It was thanks to them that the Society was in the prosperous condition which the Report revealed.

Capt. A. Carpenter, in seconding the Resolution, remarked on the great increase in the number of Fellows, for which we were chiefly indebted to our popular President. We took as a matter of course the work done by the Council as shown in the Annual Report, and expected so much from them, that in view of the advances made in the navigation of the atmosphere we should now expect them to sail about over London and decide Meteorological problems on the spot.

The Resolution was adopted.

Institution of Civil Engineers.

Mr. F. Druce proposed "That the thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution." He remarked on the great convenience it was to have such a room at their disposal, especially with the present large number of Fellows.

Mr. J. E. Clark said that it was a pleasure to second a motion of that kind, and they must all appreciate the goodness of the Institution of Civil Engineers in entertaining them for so many years. He had been wondering how long the Society had enjoyed the Institution's hospitality, and had found that it dated back to the time when Robert Stephenson was the President of the Royal Meteorological Society, and obtained for them this very generous assistance for meteorology. With the present large number of Fellows, and so rapid an increase, the importance of having such a room became more and more obvious.

The President, in putting the motion to the Meeting, remarked that he always felt that, thanks to the kindness of the Institution, they had the finest meeting room in London.

The Resolution was adopted.

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Presentation of the Symons Memorial Gold Medal.

The President said that he now approached what was the pleasantest part of his duties, because it was to render a tribute at the same time to one of the most distinguished of modern meteorologists, and to the memory of his great predecessor in that chair, and in other work, Mr. G. J. Symons. They were aware that the Gold Medal was established in memory of Mr. Symons, and was awarded every alternate year by the Society to a meteorologist for the work he had done in advancing the science. On the first occasion the Medal was awarded to the late Dr. Alexander Buchan; on the second, to the famous Austrian meteorologist, Dr. J. Hann; on the third, to Sir Richard Strachey; and on this the fourth occasion, the name of the recipient and the nature of his work would appear in an extract from the Council Minutes which the Secretary would now read.

The Secretary, Mr. H. Mellish, then read the following extract from the Minutes of the Council Meeting, dated October 16, 1907:—

"It was resolved that the Symons Memorial Gold Medal for 1908 be awarded to Monsieur Léon Teisserenc de Bort for distinguished work done in connection with meteorological science.

"Léon Teisserenc de Bort commenced his scientific work in 1878 as a member of the staff of the Bureau Central Météorologique de France. From 1880 to 1892 he was chief of the department of General Meteorology. He resigned his appointment in 1892 in order to devote himself to experimental research in meteorology. In 1896 he founded an Observatory for the study of Dynamical Meteorology at Trappes, which has become famous for the boldness of its enterprise and the success of its methods in the study of the upper air.

"M. Teisserenc de Bort has also organised and directed for special purposes in connection with that study, schemes for exploration of the upper air in Denmark and Lapland, on the Cattegat, and the Zuyder Zee. He has transformed a Hull fish-carrier into a floating meteorological observatory, which under the name of the yacht *Otaria* has carried out—partly with the assistance of Professor Rotch—extensive researches in the Mediterranean and over the inter-tropical belt of the Atlantic Ocean.

"His earlier published papers include a magnetic survey of parts of Algeria, Tunis, and the Sahara, undertaken during his periods of leave while still attached to the Bureau Central. And while head of the department, he contributed sixteen papers on the general circulation of the atmosphere; the distribution of the meteorological elements over the globe, and their mutual relations; and the distribution of barometric pressure at different levels. In this connection it is sufficient to mention the introduction of the idea of "centres of action of the atmosphere"; the relation of the anomalies of temperature and pressure; the charts of isobars for 4000 metres level, showing general cyclonic circulation round each pole above the irregularities of the surface; and the analysis of vertical motion in cyclones and anticyclones,—as important general results that constitute definite advances in our knowledge of the meteorology of the globe.

"But M. Teisserenc de Bort is best known for his work upon the upper air by means of ballons-sondes and kites. The equipment used was designed and constructed at Trappes, and the results obtained have added largely to our knowledge of the upper air. The establishment of the existence of the so-called isothermal layer at a height of about ten kilometres is largely due to the work of the Observatory. The identification of the return anti-trade above the North-east trade-wind; the structure of the intervening layer;

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and the comparison of the temperatures in the highest layers in various latitudes, which apparently show a gradient of temperature from the pole to the equator, instead of one, as might be expected, in the opposite direction, —are scientific achievements of M. Teisserenc de Bort, in collaboration, as regards some parts of the work, with colleagues of various countries.

"With Professor Hildebrandsson, M. Teisserenc de Bort has recently completed a historical treatise upon Dynamical Meteorology. The advances made in that subject by his personal exertions and at his own charges must always remain for future historians among the most original achievements of the present generation."

THE PRESIDENT, addressing M. Teisserenc de Bort, said :—

"M. Teisserenc de Bort, I feel that there is a special appropriateness in giving this Medal to you. If Mr Symons' life teaches us anything—and it teaches much—it is that the enthusiastic perseverance of an individual with a definite aim in view can often accomplish work which would be difficult for any public department to carry out officially. Like Mr. Symons, you entered the meteorological service of your country, and like him, you left it in order to pursue a definite line of research in a particular direction which had previously been neglected. Your conspicuous success claims in this country, more perhaps than in other countries, a special meed of praise, because here we are in the habit of seeing great results accrue from individual effort in scientific and public life ; and when we see the same spirit animating the people of other countries and leading to such results as you have achieved, our hearts glow with the warmest appreciation. And it is extremely gratifying that we have within our reach the means of expressing this feeling. It is indeed fitting that the Medal awarded largely for work done by free balloons should go to a countryman of the great pioneer Montgolfier. We feel a special satisfaction, also, that this Medal goes to a citizen of the country which is our nearest neighbour on the Continent, and, amongst all the friendly nations of the world, one which we hold the friendliest. It is to me, as a Scotsman, an additional gratification to claim that nation as an ancient ally of my country, and the fact that the feeling, historical in the north, is now shared by the whole United Kingdom, is surely one of the best tributes to that subordination of national boundaries to international unity which finds its best expression in the brotherhood of men of science throughout the world. I hand you the Symons Memorial Gold Medal with our heartiest good wishes."

M. TEISSERENC DE BORT said : "Ladies and gentlemen, I am very sorry that I am not able to speak English fluently in order to express to the President and the Fellows of the Royal Meteorological Society my best thanks for the great honour done me by the award of the Symons Gold Medal. I therefore ask you to allow me to speak in French.

"Je suis particulièrement sensible à cette distinction, d'autant plus que des liens de longue amitié me rattachaient à G. J. Symons dont je fis la connaissance personnelle au Congrès météorologique de 1878. J'avais annuellement le plaisir de me retrouver avec lui et nous étions en correspondance assez régulière.

"Au moment de l'Exposition de 1889, où il séjourna assez longtemps à Paris, il se préoccupait d'un problème qui fixe depuis quelques années, d'une manière particulière, l'attention des météorologistes et qui consiste à déterminer la liaison entre les divers phénomènes qui accompagnent les orages et les grains, tonnerre, pluie, vent, grèle, etc.

"L'appareil qu'il inventa à ce sujet, le brontomètre, permet à l'observateur de déterminer exactement le temps auquel commence ou finit un phénomène donné.

"La commission d'étude du Krakatoa, présidée par Symons, fit faire un grand

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LÉON TEISSERENC DE BORT.

(*Symons Medallist*, 1908).

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pas à la connaissance de la circulation générale de l'atmosphère en démontrant l'existence d'un courant E.O. au-dessus des régions équatoriales jusqu'à une très grande hauteur et mesurant sa vitesse par le déplacement des cendres du volcan.

"Ainsi Symons qui avait déjà créé en Angleterre cet admirable service de la mesure de la pluie, d'une si grande utilité,—et avait su le faire vivre par des ressources privées,—donna aussi une notable partie de son temps à l'étude de l'atmosphère dans ses mouvements généraux.

"Au moment où l'étude de l'atmosphère libre prend une si grande extension, comme nous le rappelait si bien Mr. le Président dans son discours, nous devons regretter encore plus que G. J. Symons ne soit plus au milieu de nous pour participer à ces recherches si captivantes.

"Permettez-moi de vous exprimer de nouveau tous mes remerciements pour la belle médaille qui vient de m'être donnée et qui porte en effigie un excellent portrait de G. J. Symons. C'est une distinction dont je sens tout le prix ; en même temps cet objet précieuse évoquera en moi le souvenir d'une précieuse amitié."

[A portrait of Monsieur Léon Teisserenc de Bort is given on Plate II.]

PRESIDENT'S ADDRESS.

THE PRESIDENT then delivered an Address on "Map-Studies of Rainfall" (p. 65).

Dr. W. N. SHAW, in proposing that "the thanks of the Society be given to Dr. Mill for his services as President and for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal*," remarked that Dr. Mill had anticipated the latter part of the resolution by intimating that he would give permission for the Address to be printed in the *Quarterly Journal*. As regards the former part, he, Dr. Shaw, trusted that Dr. Mill would allow him to include the Address among the services of the President, for he thought the Address could be regarded as one of the greatest of these services. Dr. Mill was much to be congratulated on his year of office : there was, first, the remarkable increase in the number of Fellows ; secondly, the development of the investigation of the upper air, appropriately represented by M. Teisserenc de Bort's presence that evening ; and, thirdly, the remarkably interesting Address they had just heard.

He would like to touch on two points in the Address. Dr. Mill proposed to regard the shower as a unit for the study of rainfall, thereby associating himself with workers in other branches of the subject. The closer investigation of the shower promised to be a starting-point of very important work in dynamical meteorology as well as in rainfall. Then he wished to emphasise the enormous advantage of coloured maps, which had been proved so conspicuously during the Address. Perhaps Dr. Mill would tell them how to get reproductions of maps printed in colour, in such a way as to form illustrations in the *Journal* as effective and satisfactory as the maps shown on the wall.

Mr. W. H. DINES seconded the Resolution.

The Resolution was adopted.

THE PRESIDENT, in reply, said that with regard to the coloured maps no difficulty need arise except with the Exchequer. He thanked them very much for their reception of his Address, for the silent attention with which they had listened to it, and for the generous applause with which the Resolution had been carried.

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Election of Council.

The Scrutineers then declared the following to be the Council for the ensuing year:—

President.

Hugh Robert Mill, D.Sc., LL.D., F.R.S.E., F.R.G.S.

Vice-Presidents.

Richard Bentley, F.L.S., F.R.G.S.
William Henry Dines, B.A., F.R.S.
Edward Mawley, F.R.H.S.
William Napier Shaw, M.A., D.Sc., F.R.S.

Treasurer.

Charles Theodore Williams, M.A., M.D., F.R.C.P., M.V.O.

Secretaries.

Francis Campbell Bayard, LL.M.
Henry Mellish, D.L., J.P., F.R.G.S.

Foreign Secretary.

Robert Henry Scott, M.A., D.Sc., F.R.S.

Councillors.

Walter William Bryant, B.A., F.R.A.S.
Capt. Warren Frederick Caborne, C.B., F.R.G.S., F.R.A.S.
Capt. Maurice Harvey Clarke, F.R.A.S., F.R.G.S.
Richard Henry Curtis.
Henry Newton Dickson, M.A., D.Sc., F.R.S.E., F.R.G.S.
Francis Druce, M.A., F.R.G.S.
William Ellis, F.R.S., F.R.A.S.
Capt. Melville Willis Campbell Hepworth, C.B., F.R.A.S.
Richard Inwards, F.R.A.S.
Baldwin Latham, M.Inst.C.E., F.G.S.
Rudolf Gustav Karl Lempfert, M.A.
Capt. David Wilson-Barker, F.R.S.E., F.R.G.S.

February 19, 1908.

Ordinary Meeting.

Dr. Hugh Robert Mill, President, in the Chair.

Md. Mufazzal Hoosein, Camp Sibsagarh, Assam;
Percy Richard Jameson, 98 Clerkenwell Road, E.C.;
George Robert Jebb, M.Inst.C.E., Great Barr, Birmingham;
Capt. James Robert Rae, 73 Caledonia Road, Saltcoats, N.B.;
Sriram Venkata Subba Setti, B.A., Chikmagahur, Mysore;
Capt. Henry Strong, Union-Castle Co., Fenchurch Street, E.C.;
Octavius Thomas, Pentre, Rhondda, Glam.;
John Wrench Towse, Sunnydene, Bickley;
Frank Woolnough, Museum, Ipswich; and
John Howie Wylie, Heath House, Woking,
were balloted for and elected Fellows of the Society.

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THE PRESIDENT said that before proceeding to the ordinary business, it was his melancholy duty to record the deaths of several distinguished members of the Society. These losses had been particularly numerous lately among the Honorary Members. They had now to deplore the death of Monsieur A. Lancaster, the head of the Meteorological Service of Belgium, and there were four vacancies in the list of Honorary Members. General Sir Richard Strachey, who had received the Symons Memorial Gold Medal in 1906, had ended his long and brilliant career. Both the British holders of this Medal were now no more. The varied contributions to Meteorological Science by Sir Richard Strachey had been brought so fully before the Society in 1906, that it was unnecessary to dilate upon them now; but he must give expression to their deep regret at the passing of so magnificent a veteran.

He wished to refer to several points in the activity of the Society. One was that no less than 180 Essays had been received in response to the Society's request to teachers to submit specimen lessons on Meteorology. The extremely laborious task of going through these had been commenced, and it was hoped that the result might soon be announced. There was to be a meeting of meteorologists of the British Empire in May at Ottawa, which would be the first attempt made to unite the meteorologists of the Empire in conference. An invitation had been received from the Royal Society of Canada to send a delegate. The time of year selected made it difficult for many meteorologists to get away from their more immediate duties, but the Society hoped that Dr. Shaw would act as its representative to convey their good wishes.

The President concluded by remarking that the next Meeting of the Society would take place on the 11th instead of the 18th of March, when their distinguished Honorary Member, Professor Hellman, would give them a lecture on the "Dawn of Meteorology." Most of them were aware that Dr. Hellmann had last visited them on the occasion of their Jubilee; he was a fluent English speaker, and he—the President—trusted all the Fellows would unite in making the meeting one of the largest and most successful ever held by the Society.

The following communications were read:—

1. "FORMATION OF SNOW-ROLLERS." By CHARLES BROWETT (p. 87).

2. "COMPARISON OF SHIPS' BAROMETER READINGS WITH THOSE DEDUCED FROM LAND OBSERVATIONS." By ERNEST GOLD, M.A., F.R.Met.Soc. (p. 97).

CORRESPONDENCE AND NOTES.

Lectures on Meteorology.

Mr. W. MARRIOTT has recently given lectures on meteorological subjects, in connection with the Society's scheme for diffusing a knowledge of Meteorology, at the following places: January 29, Charterhouse, Godalming; March 6, Reading School, Reading.

Prize Competition for Teachers.

The Council of the Royal Meteorological Society have considered the Reports of the Examiners on the Essays on "Climate or Weather," which were sent in by elementary teachers for the prize competition mentioned on p. 55 of the last No. of the *Quarterly Journal*, and have made the following awards:—

1st Prize, £5, W. C. Upshall, Broughton, Stockbridge.

2nd Prize, £3, Miss A. B. Phillips, 34 Blythe Hill, Catford.

3rd Prize, £2, Albert V. Stevenson, St. Paul's School, Sunderland.

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Extra Prizes, £1 each—John Young, Barrock School, by Wick; Henry Collar, Lavender Hill School, Clapham Junction.

In addition to the above, the following prizes have been awarded for Essays sent in by Pupil Teachers:—

1st Prize, £1, Arnold B. Tinn, 28 Macaulay Road, Birkby, Huddersfield.

2nd Prize, 10s., Miss Daisy E. James, Church House, Wokingham.

Meteorological Work at the Radcliffe Observatory, Oxford, 1907.

The usual meteorological observations and automatic registrations have been maintained, and the results forwarded regularly as heretofore to the Meteorological Office (by daily telegram), the Registrar-General, the Thames Conservancy, the Metropolitan Water Board, local newspapers, to public and sanitary authorities, and numerous private inquirers.

During the year 1907 the five underground platinum thermometers were read daily. Observations made with these thermometers have been carried on without interruption since November 1, 1898, but it is intended to discontinue their regular use at the end of 1909. At the request of the Director of the Meteorological Office, daily comparisons have been made between the platinum thermometers and two ordinary mercurial thermometers of Symons's underground pattern at depths of 6 ins. and 3 ft. 6 ins.

All the automatic instruments have worked well during the year.

The following are the chief characteristics of the weather noted at Oxford during the year 1907:—

The mean reading of the barometer (reduced to 32° F.) was 29·737 ins., which is 0·010 in. higher than the mean for the preceding 52 years. The highest reading, 30·626 ins., occurred on January 23; the lowest was 28·571 ins. on December 13.

The mean temperature of the air for the year was 48°·7, or 0°·2 below the mean for the preceding 79 years. The maximum temperature was reached on May 12, viz. 78°·5, and the minimum 20°·2 on January 25. The lowest reading of the thermometer exposed on the grass was 12°·7 on February 3.

The differences of the mean monthly temperatures from the corresponding means for the preceding 79 years are

Jan.	+0°·2	May	−0°·3	Sept.	+1°·1
Feb.	−1·9	June	−3·5	Oct.	+1·1
Mar.	+2·6	July	−3·8	Nov.	+1·5
April	−0·4	Aug.	−1·2	Dec.	+2·0

Bright sunshine was recorded during 1432 hours, or 32 hours less than the mean for the preceding 26 years. The monthly differences from the mean are indicated in the following table:—

	hrs.		hrs.		hrs.
Jan.	+25	May	−57	Sept.	+21
Feb.	+25	June	−61	Oct.	+ 1
Mar.	+74	July	−36	Nov.	+ 2
April	−17	Aug.	− 9	Dec.	− 1

Rainfall on the ground amounted to 27·024 ins., a total which is 0·997 in. above the average for the preceding 92 years.

The number of "rainy days" (*i.e.* 0·010 in. and over) was 155.

The divergences of the monthly totals from the corresponding mean values for the previous 92 years were

	ins.		ins.		ins.
Jan.	−1·349	May	+0·363	Sept.	−1·874
Feb.	−0·504	June	+0·637	Oct.	+2·493
Mar.	−0·739	July	+0·833	Nov.	−0·099
April	+0·506	Aug.	−1·100	Dec.	+1·830

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A fine display of aurora borealis was observed on February 9.

On January 21, 1907, Mr. E. E. M'Clellan, who had held the post of third assistant since 1892, died rather suddenly. His connection with meteorology was a long one. Previously to his appointment at Oxford he had served for 12 years in the magnetical and meteorological department of the Royal Observatory, Greenwich. He was an accurate observer and a good computer, possessing also considerable skill in photography.—ARTHUR A. RAMBAUT, Radcliffe Observer, March 2, 1908.

Tropical and Sub-Tropical Cyclones in North-West of Madagascar.

For some years past the number of cyclones north-west of Madagascar has considerably increased.

So far as I am aware, no tropical cyclones have ever been recorded in the Cosmoledo and Aldabra groups. The only record of a cyclone northward of this latitude and at an earlier date is that which visited the Seychelles groups 45 years ago (October 1862).

Mr. James Spurs, formerly lessee of these islands, once told me that a cyclone visited these islands some 20 years ago; but no sufficient information could be obtained from him to prove that it was a cyclone, as he himself was absent from the island at the time. There were only some fishermen on the island, and not one amongst them could note phenomena during a storm. But according to the scanty information which Mr. Spurs related to me, and which he had gathered from his fishermen, I quite agree with our old island meteorologist that this was a cyclone that curved south-eastward of Aldabra island early in the month of October.

To my knowledge the most northern limit where cyclones, northward of Madagascar, curved was over the islands of Farquhar and Glorieuse, and they very often caused great damages to property.

The cyclone which visited Astore, Cosmoledo, and Aldabra islands on November 2 and 3, 1907, was an unprecedented one for these islands, with regard to time of the year, the direction and force of the wind, and the suddenness, rapidity, and extent of changes which took place.

According to the information gathered from the manager of these islands, it appeared that the weather had been threatening since the preceding day with sinister aspect. Towards the afternoon on November 2 the wind blew in sudden gusts from southward, with high, tempestuous sea, and there were loud thunder and vivid lightning at times. At midnight the wind increased violently, and veered from South to South-west. Thunder continued at frequent intervals in the south, south-west, overhead, and north-west, with blinding lightning; and the roaring of the waves over the surf was something frightful. Towards the morning, on November 3, the wind veered to West and North-west, where it remained steady and blew a hurricane of much violence.

During that time Astore and Cosmoledo islands were devastated by that tempestuous foul weather.

Heavy rainfall, accompanied by wind and sea, flooded the cocoa-nut plantations in the lagoon at Astore, the opening of the lagoon being in the south-western part of the island; and so, when the wind veered to the South-west and West, enormous quantities of water were sent into the lagoon. Signs of the flood can still be seen at a distance of 100 yards from the beach, in the lagoon, right in the plantations.

Most of the bigger cocoa-nut trees on Astore and Cosmoledo islands were blown down by this terrible hurricane. The inhabitants suffered much during this dreadful time.

All the houses were blown down; the manager's house at Cosmoledo was shifted to a distance of about 18 feet from west to east, the roof of the house

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was carried away to a distance of about a quarter of a mile by the strength of the Westerly wind. Some of the labourers' huts have never been seen again. Numbers of corrugated iron sheets were seen flying in the air like birds, cutting down small trees here and there like sharp axes, and have never been picked up again, having been blown right out into the sea.

At Aldabra the same weather was experienced, but not so foul, the wind blowing in the same direction and force as at Astore and Cosmoledo, but no rain, thunder, or lightning was observed; only the weather was dark and gloomy, all indicative of an advancing storm. There was a barometer on the island, and Mr. Sauzier, the manager, told me that it fell to a little over 29·50 ins., when the wind was blowing at its strongest from West to North-west, and steady. Towards the afternoon, on November 3, the conditions were more promising, wind and sea abating, and there was appearance of better weather.

Correct observations could not be obtained, as there were no instruments available on the island for the purpose of recording meteorological observations.

According to the information received this was a cyclone, with all the characteristics of a small diameter, and the centre must have passed southward of Astore and Cosmoledo islands.—Capt. R. Parcou, Victoria, Seychelles.

Scintillation and Rippling of Distant Lights.—I was at Brighton from March 12 to 20, 1908, and made the following observations on the scintillation of the lights at Worthing as seen from Brighton for comparison with those by Mr. Marriott in the *Quarterly Journal*, 24, p. 50.

Time.	Wind.	Force.	Weather.	Worthing Lights.
March 12, 8 p.m.	NE.	1	Fine, moonlight	Lights steady.
,, ,, 10 ,,	Calm	0	Sea fog	Lights invisible.
,, 13, 8 ,,	S.	2	Cloudy	Lights scintillating and undulating rapidly.
,, ,, 10 ,,	S.	1	Fine, moonlight	Lights scintillating.
,, 14, 8 ,,	ESE.	2	Fine, misty	Lights invisible.
,, ,, 10 ,,	,,	2	,,	,,
,, 15, 8 ,,	Calm	0	Overcast	Lights steady.
,, ,, 10 ,,	,,	0	,,	,,
,, 16, 8 ,,	W.	1	Fine, moonlight	Lights scintillating.
,, ,, 10 ,,	,,	2	,,	Lights scintillating and undulating rapidly.
,, 17, 8 ,,	NNW.	1	Fine, foggy	Lights invisible.
,, ,, 10 ,,	,,	1	,,	,,
,, 18, 8 ,,	N.	1	Fine	Lights steady.
,, ,, 10 ,,	,,	1	,,	,,
,, 19, 8 ,,	NE.	2	,,	,,
,, ,, 10 ,,	,,	2	,,	,,

It would appear that an off-shore breeze, or the absence of any breeze, is unfavourable to the phenomenon.—Spencer C. Russell, Epsom, Surrey.

Exciting Balloon Adventure.

The Hon. Mrs. Assheton Harbord has given in *The Times* the following interesting account of a recent balloon voyage across the Channel to France:—

"I left Battersea Gasworks in my balloon, the *Valkyrie*, 60,000 cubic feet, at 9.45 on Friday night, January 31, to make an attempt to win the Northcliffe Challenge Cup for the longest distance travelled during the present year. Mr. J. F. Pollock accompanied me as pilot, this being his seventh crossing and my third. We had considerable difficulty in getting away owing to the high wind that prevailed; but taking advantage of a momentary lull we cleared a very high gasometer and went straight up to a height of 2500 ft. We took with us 17 45-lb. bags of ballast, four of which we used in the first three-quarters of an

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hour. At 10.30 the *Valkyrie* encountered a violent squall, which caused the car to sway to such an extent that we had to hold on to avoid being thrown out. We sighted the coast at 10 minutes to 11, and left it at 11.7, an hour and 20 minutes from the time of starting from Battersea. We were then at a height of 3700 ft. The night was very dark, but we gathered from the bend of the coast that we were leaving the land to the right of Dungeness. In the middle of the Channel we could see the revolving lights on both coasts; and recognising Boulogne, we concluded that we were passing over the French coast near Le Touquet, which we afterwards found to be correct. We sighted the land at 11.20, and reached the coast at two minutes to 12 at a height of 3700 ft., the crossing having taken 51 minutes. The sea crossing was the quietest and the most uneventful part of the voyage, for at 1.30 we experienced strong vertical currents which made the balloon shoot up very rapidly, and when it encountered a downward vertical current it fell with great speed, making a continuous discharge of ballast necessary. There was a good deal of sheet lightning, and the atmospheric conditions were very curious. The car hoop and neck of the balloon seemed illuminated as if by electric light, which, when I rubbed it, made my glove appear alight. At 2 o'clock we encountered a terrific snowstorm, which covered us and half filled the balloon, which was considerably affected by the extra weight thus thrown upon it. Subsequently we again found ourselves rising very rapidly, and after attaining an altitude of 8000 ft. we discovered that we were falling equally rapidly. The discharge of five bags of ballast in four minutes had no effect in checking the descent, and suddenly at a height of 1500 ft. the bottom of the car crashed down on something with great force. The trail rope then began catching in everything it could find, giving the car very violent jerks. We were dashing along at a terrific speed, and the night was so dark that I could scarcely distinguish Mr. Pollock, the roaring of the wind combined with the heavy snow making us extremely anxious, as the last bag of ballast had not the slightest effect on the balloon; and having only three bags left, we realised there was no alternative but to make a descent, and chance where we should land, as we were completely enveloped in darkness. So Mr. Pollock opened the valve, while I crouched low down in the car, feeling rather thrilled at what might happen. Down we crashed with great force straight into some trees. Mr. Pollock ripped at once, but the wind carried us up again, and down we came with the basket overturned. Mr. Pollock shouted out, 'Are you in?' and I called back, 'Yes,' for I was holding on for all I knew, the violent encounters with the trees making it very difficult to avoid being thrown out. At last a tree caught the envelope, causing a large tear, which, combined with the rip, brought us to a standstill. After we had collected our senses we got out and found we were in a dense forest, far away from any habitation. There was nothing for it but to wait till dawn, and conjecture what country we had descended in. At about 6 it became light, so we started off to get out of the forest, and after half an hour's walking we found ourselves on a main road, along which we walked for an hour. At last we discovered a man cutting trees,whom we hailed, and discovered from him we had descended in the department of the Meuse near the small village of Haudiomont. We made him walk back with us to show him where we had descended, and he promised to return with a cart, which he did in three hours. In the meantime we had been discovered by more wood-cutters, who set to work to help us, and with their assistance we packed up the balloon. The envelope being high above us on the trees it was with much difficulty we got it down, and also the trail rope, which was stretched far away on the tree-tops. We also had to collect various pieces of the balloon envelope, which we discovered hanging from branches, on one of which we found the feed pipe, which had been entirely torn off. Unluckily we smashed all our instruments, the first crash quite settling the

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statoscope. The drive of ten kilomètres to Verdun took eight hours, as the horses went at a snail's pace, and a remarkably cold drive it was in a bitterly cold wind. If we could possibly have weathered the storm we could have had a tremendously long run, but there was no alternative for us under the circumstances but to descend. A great deal was due to Mr. Pollock for his presence of mind and quick action when every minute was of the utmost importance, for it takes a good deal of nerve to make a descent in a pitch-dark night without the faintest idea of what one will land on. It was a thrilling experience, and, though the distance accomplished will, no doubt, soon be beaten, it was a very sporting run, and one always to be remembered."

Rainfall of the Atlas Lands.

The most complete study yet made of the precipitation conditions of North-West Africa (Morocco, Algeria, and Tunis) is that of Dr. Karl Knoch, which appears in the *Jahresbericht* of the Frankfurt Association for Geography and Statistics (17 Jahrgang, Frankfurt am Main, 1907). It occupies 86 pages, and embodies in a generalised form all the data on the subject at present available. For Algeria, and in a less degree for Tunis, they are fairly extensive, and some of the series of observations extend over a considerable number of years. For Morocco the case is different, though observations have been made at certain stations within recent years, while a general discussion of the climate has been supplied by Dr. Theobald Fischer, to whom Dr. Knoch owes the suggestion which led him to undertake the present work. After some preliminary matter the author proceeds to discuss the distribution of the rainfall in space and time. The most striking fact is the great variation between different parts of the region. As regards the former, it may be said that, taken as a whole, the rainfall diminishes from the coast to the interior, and also from east to west, the most rainy region of all being that of the highlands of northern Tunis, though most of the Algerian Tell is well supplied. An exception to this general rule is formed by the Atlas of Morocco, where naturally the rainfall again shows a marked increase, after falling to a low figure over the outer plateau. Taken as a whole the Atlas region falls within the realm of winter rainfall, with dry or almost dry summer, though this does not hold good beyond a limited distance from the coast. The summer drought is especially pronounced along the whole coast of Algeria and Tunis. On an average, the largest amount of rain falls in January in western Algeria ; but farther east, in December.

In Morocco the distribution seems to be somewhat different, so far as can be judged from the still scanty data. In the south there is a small amount of rain even in July and August, the driest months (the most rainy month being November), while farther south they are quite rainless. In this direction the amount of winter rain also shows a relative diminution. In Mogador, *e.g.*, there is a subordinate maximum in March, beside the main maximum in December. With the increase in height as we go inland the summer drought is moderated, while throughout the whole interior the spring is the most rainy season.

A section of the paper deals with the water-supply of the rivers, which varies greatly in different parts of the region and at different times of the year. Most of the rivers reach a very low level during the summer drought unless they are fed from the region of spring rainfall or from melting snows. Morocco, owing to the greater height of the Atlas towards the west, is more favourably placed than Algeria or Tunis in this respect. Another instructive section is devoted to a consideration of the relations of vegetation to rainfall, and this is further illustrated by a vegetation map on tracing paper, which can be placed over the rainfall map. The fact that no regular cultivation is possible where

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the precipitation is less than 400 mm. (15·7 ins.) is clearly brought out. A series of tables gives the rainfall statistics for a large number of stations, showing *inter alia* both the mean amounts and the percentages of the yearly total for each month and season.—*Geographical Journal*, December 1907.

Mount Weather Observatory.

The U.S. Weather Bureau during the last few years has founded and equipped the Mount Weather Observatory, which is specifically devoted to research work. It is 1725 feet above sea-level, and is located in Virginia, on the top of the Blue Ridge Mountains, some 20 miles south of Harper's Ferry and 47 miles in a direct line from Washington. It is only 6 miles from Bluemont, the nearest railway station, and is easily reached from that point along an excellent mountain road. It overlooks to the west the entire Shenandoah Valley from Strasburg to Harper's Ferry, while to the east all that portion of Piedmont Virginia between the Blue Ridge and the Bull Run Mountains is in full view. This extensive sweep of valleys, mountains, and plains affords rare opportunities for the study of storm formation and action. This location is satisfactory for the physical laboratory and for the magnetic observatories. For solar work it is as well adapted as any place east of the Rocky Mountains; while for the study of the upper air it is peculiarly well situated, since kite flights can be obtained there almost daily through the entire year.

The *Bulletin of the Mount Weather Observatory*, which will be published quarterly, will contain more or less detailed accounts of the researches conducted at that place. The first number has just been issued, and contains two papers, viz.: (1) "The Methods and Apparatus used in obtaining Upper Air Observations at Mount Weather," by Dr. W. R. Blair; and (2) "The Use of Upper Air Data in Weather Forecasting," by Prof. A. J. Henry (see below).

The Use of Upper Air Data in Weather Forecasting.

Prof. A. J. Henry, who is one of the forecasters of the United States Weather Bureau, during the summer of 1907 had the opportunity of comparing upper air conditions as obtained by kite flights at Mount Weather, Va., with the general meteorological conditions over the eastern part of the United States, as shown by the 8 a.m. daily weather map. The general conclusions which he believes may be drawn from the data thus far collected, are the following:—(1) The air column in the "low" is warmer than in the "high" for such altitudes as were reached by the kites; (2) the region of greatest cold is found in the south-eastern quadrant of the "high"; (3) as the centre of the "high" crosses the meridian of the station, and passes to the eastward, the temperature conditions aloft become more or less unstable, inversions take place, and the rate of decrease of temperature with increase of altitude diminishes.

Occasionally in the kite flights layers of air are met having temperatures higher than those found in layers of less altitude; in other words, the vertical gradient is interrupted, and instead of a fall in temperature with increase in altitude a rise is found. Such breaks in the continuity of the vertical temperature gradient are known as inversions.

Temperature inversions may be classed as follows: First, those which occur in the rear of a "low" or on the immediate eastern front of a "high." Inversions in this region are thought to be due to the circumstance that the warm surface layers of the "low" feel the cooling effect of the "high" a little sooner than the layers at some distance aloft. This assumption follows the suggestion of Mr. Helm Clayton, of the Blue Hill Observatory, viz., that the cold air of the northern portion of the "high" moves more rapidly east-south-east than does the "high" itself, and that, on account of its greater specific weight as compared with that of the air into which it is moving, it sinks

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toward the earth's surface in an inclined stratum which reaches the ground in the rear of the "low." This type of inversion has little or no significance to the forecaster, since, ordinarily, cooling in the rear of the "low" proceeds until the upper layers, within the limits of observation at least, acquire a temperature nearly such as is required by the adiabatic rate of cooling for dry air.

A second type of inversion is met when the kites pass from one current of air into another having a different temperature. The existence of a current of warm air flowing along and above a colder one is revealed in this way. Inversions of this nature sometimes afford early indications of the approach of warmer conditions at the surface. The difficulty in properly applying this information at present lies in the fact that the horizontal extension of the warmer current is unknown.

The rate of decrease of temperature with increase of altitude is almost constantly changing, being generally different in the forenoon from what it is in the afternoon. The sequence of changes in this element in its relation to the drift of "highs" and "lows" appears to be about as follows:—In the region of cold, dry winds, which is found on the eastern front of a "high," it approaches closely to the adiabatic rate for dry air, viz., 1° F. in 185 ft., or 1° C. in 100 metres. From this rate, which is maximum, it begins to diminish with the shift of the winds to an Easterly quarter, and the consequent increase in their moisture content. The rate in rainy weather is rather variable, sometimes almost zero up to a height of nearly a mile, and again being much greater. The rate of decrease most frequently observed was about 3°·5 F. per 1000 ft., or 0°·6 C. per 100 metres. The forecasting value of this phenomenon (the vertical temperature gradient) is not yet understood.

Meteorology in the Antarctic.

Dr. W. S. Bruce has received word that the *Uruguay* has returned from Scotia Bay, South Orkneys, bringing with her the party from the Meteorological Station on that island, and having left behind the relief party to continue the work for another year. This relief party was on the *Austral*, which was wrecked, but the party was immediately transferred to the *Uruguay*, which accomplished the journey in safety.—*Scottish Geographical Magazine*, April 1908.

RECENT PUBLICATIONS.

Airships Past and Present. Together with Chapters on the Use of Balloons in connection with Meteorology, Photography, and the Carrier Pigeon. By A. HILDEBRANDT, Captain and Instructor in the Prussian Balloon Corps. Translated by W. H. STORY. London: Archibald Constable and Co. 1908. 8vo. 16 + 364 pp. and plate.

This work gives in an interesting manner a survey of the development of the art of ballooning from the earliest times. The author was a member of the International Commission, which was appointed to consider matters connected with the application of ballooning to scientific ends, and he has worked with Prof. Assmann and Prof. Hergesell. He is able to speak from personal knowledge of what has been done by means of balloons and also by kites to investigate the upper atmosphere.

The work contains more than two hundred illustrations, many of which are of meteorological interest.

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Meteorological Atlas of the Indian Seas and the North Indian Ocean. A Series of Weather Charts with descriptive Text, prepared chiefly by W. L. DALLAS of the Meteorological Department of the Government of India, under the direction of GILBERT T. WALKER, M.A., D.Sc., F.R.S., Director-General of Observatories in India. 1908. Messrs. John Bartholomew and Co., Edinburgh. Size 15 × 12 inches.

This Atlas consists of thirty-six charts, which are printed in colours. The first twelve charts show for each month the average conditions of atmospheric pressure, the direction and force of the normal winds, and the sea-currents. Opposite each month short descriptive remarks are given, drawing attention to the changes which have occurred in the weather since the preceding month, and to the most marked meteorological features of the month under review.

The nine charts which follow show the ordinary tracks of storms over the Arabian Sea and the Bay of Bengal for each of the stormy months of the year, and a short account of the principal features of the tracks of storms in the different months is given in the text.

The last fifteen charts of the Atlas exhibit the conditions prevailing over the Arabian Sea and the Bay of Bengal during the existence of typical storms of those seas. These charts not only show the movements of the selected storms over the sea-area from day to day, but exhibit the winds and weather actually recorded by ships traversing the Indian seas during the existence of the storms, and also the areas over which the storm influence extended.

Meteorological Charts of the Southern Ocean between the Cape of Good Hope and New Zealand. Second Edition. Published by the Authority of the Meteorological Committee. Official No. 123. London, 1907.

These charts were originally issued in 1899, and were noticed in the *Quarterly Journal*, 1900, 26, p. 283.

In this second edition the scale of the Wind, Barometer, Air Temperature, and Fog charts have been reduced, as well as that of the charts of the Sea-Temperature Isothermals, to make the publication more handy. On the other hand, the scale of the current charts has been slightly increased, and charts have been added to show the distribution of ice. The work has been carried out under the superintendence of Capt. Hepworth, Marine Superintendent.

Scottish National Antarctic Expedition. Report on the Scientific Results of the Voyage of s.y. "Scotia" during the Years 1902, 1903, *and* 1904, *under the leadership of* WILLIAM S. BRUCE, LL.D., F.R.S.E. Volume II. Physics. Edinburgh, 1907. 4to. 324 pp. and plates.

This volume is devoted almost entirely to the meteorological results of the expedition, which were in the capable hands of Mr. R. C. Mossman. The observations are given *in extenso*: (1) Those taken at sea; (2) at Scotia Bay, April 1 to October 31, 1903; (3) at Omond House, Laurie Island, South Orkneys, November 1, 1903, to February 21, 1904; and (4) at Cape Pembroke, Falkland Islands, 1903-1904.

Mr. Mossman gives a full discussion of the whole of these observations, and the results are shown graphically in a number of coloured diagrams.

Part II. contains a discussion of the magnetic observations by Dr. C. Chree and Mr. R. C. Mossman.

Part III. contains a brief report by Sir G. H. Darwin on the tidal observations.

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METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of more general interest.

Åkerblom, F.—Recherches sur les courants les plus bas de l'atmosphère au-dessus de Paris. *Nova Acta Regiae Soc. Scient., Upsala*, Ser. 4, **2**, 1908. No. 2.

Bell, H.—Thunderstorms at the Ben Nevis Observatories and on the Scottish Coasts. *J. Scot. Met. Soc., Edinburgh*, **14**, 1907 (119-133).

Bentley, W. A.—Studies of Frost and Ice Crystals. *Monthly Weather Rev., Washington*, **35**, 1907 (397-403, 439-444).

Besson, L.—Comparaison des observations actinométriques faites en divers points de la France et en Belgique pendant le mois de septembre 1907. *Ann. Soc. Mét. France, Paris*, **55**, 1907 (213-215).

Bigelow, F. H.—Studies on the Vortices in the Atmosphere of the Earth. *Monthly Weather Rev., Washington*, **35**, 1907 (464-480).

Blair, W. R.—The Methods and Apparatus used in obtaining Upper Air Observations at Mount Weather, Va. *Bull. Mount Weather Obs., Washington*, **1**, 1908 (12-57 and 12 pl.).

Boeddicker, O.—Black Rain in Ireland, October 8-9, 1907. *Symons' Meteor. Mag., London*, **43**, 1908 (2-4).

Börnstein, R.—Die Förderung der Wettervorhersagung durch das Beobachten kleiner Luftballons. *Wetter, Berlin*, **25**, 1908 (2-6).

Brodie, F. J.—The Weather of January 1908. *Symons' Meteor. Mag., London*, **43**, 1908 (17-18).

Brückmann, W.—Das Vektorazimut beim Beginn magnetischer Störungen. *Meteor. Zeits., Brunswick*, **24**, 1907 (546-548).

Bruhnes, B.—Sur l'enregistrement des courants telluriques au Puy de Dôme et la perturbation magnétique de 9 au 10 février 1907. *Ann. Soc. Mét. France, Paris*, **55**, 1907 (181-182).

Clayton, H. H.—The Lagging of Temperature Changes at great Heights behind those at the Earth's Surface, and Types of Pressure Changes at different Levels. *Monthly Weather Rev., Washington*, **35**, 1907 (457-458).

Cœurdevache, P.—Pluie à Perpignan suivant la position des hautes pressions. *Ann. Soc. Mét. France, Paris*, **55**, 1908 (203-205).

Dufour, C.—Sur le dépouillement et la détermination de la correction des enregistreurs. *Ann. Soc. Mét. France, Paris*, **55**, 1907 (218-221).

Durand-Gréville, E.—La relation du centre de la dépression avec la ligne de grain. *Ann. Soc. Mét. France, Paris*, **55**, 1907 (201-202).

Ellis, W.—Greenwich Air Temperature. *Symons' Meteor. Mag., London*, **42**, 1907 (211-214 and pl.).

Gockel, A.—Über den Ionengehalt der Atmosphäre. *Meteor. Zeits., Brunswick*, **25**, 1908 (9-19).

Goutereau, C.—Pluies et inondations en octobre 1907. *Ann. Soc. Mét. France, Paris*, **55**, 1907 (215-218).

Hann, J.—Der tägliche Gang der Temperatur in der äusseren Tropenzone. B. Das indische und australische Tropengebiet. Reprinted from *Denks. der math.-natur. Kl. der K. Acad. der Wissen., Vienna*, **81**, 1907 (93).

Hann, J.—Ergebnisse der meteorologischen Beobachtungen am Ätna Observatorium. Temperatur und Luftdruckgradienten in 3. km. Seehöhe zwischen 37° und 47° N. Br. *Meteor. Zeits., Brunswick*, **24**, 1907 (529-534).

Henry, A. J.—The Use of Upper Air Data in Weather Forecasting. *Bull. Mount Weather Obs., Washington*, **1**, 1908 (58-63 and 3 pl.).

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Jaerisch, P.—Zur Theorie der Luftdruckschwankungen auf Grund der hydrodynamischen Gleichungen in sphärischen Koordinaten. *Meteor. Zeits., Brunswick*, **24**, 1907 (481-498).

Klengel, F.—Die Niederschlagsverhältnisse von Deutsch-Südwestafrika. *Wetter, Berlin*, **24**, 1907 (253-255); **25**, 1908 (13-17, 36-40).

Köppen, W.—Die Windrichtung in 800 Drachenaufstiegen und 44 "Abreissern" bei Hamburg, 1903-1906. *Ann. d. Hydrog. u. marit. Met., Berlin*, **36**, 1908 (49-63).

Lancaster, A.—Discours prononcés aux funérailles de M. A. Lancaster, par MM. Mourlon, Goedseels, J. Vincent, G. Lecointe, et E. Lagrange. *Ciel et Terre, Brussels*, **28**, 1907-8 (577-589).

Lempfert, L. G. K.—The Daily Weather Report. *J. Scot. Met. Soc., Edinburgh*, **14**, 1907 (134-140).

Lindemann, A.—Mittlere, grösste und kleinste Monats- und Jahressummen des Niederschlags, 1866-1905. *Wetter, Berlin*, **24**, 1907 (265-272).

Lockyer, W. J. S.—Multiple Lightning Flashes. *Knowledge, London*, **4**, 1907 (241-244).

Lodge, Sir O.—Fog and its Mitigation. *The Times, Engineering Supplement, London*, Jan. 29, 1908.

Marchand, E.—Observations du courant tellurique sur la ligne télégraphique de l'observatoire du Pic du Midi. *Ann. Soc. Mét. France, Paris*, **55**, 1907 (183-186).

Marchand, E., and Bruhnes, B.—Comparaison des courants telluriques au Puy de Dôme et au Pic du Midi. *Ann. Soc. Mét. France, Paris*, **55**, 1907 (186-188).

Marriott, W.—Notes on Meteorology. *Knowledge, London*, **4**, 1907 (283-284), **5**, 1908 (16-17; 40-41).

(Marriott, W. J.)—Schools and the Weather. How Children might be taught to Study the Weather. *Daily Express, London*, Dec. 20, 1907.

Mecking, L.—Die Treibeiserscheinungen bei Neufundland in ihrer Abhängigkeit von Witterungsverhältnissen. *Ann. d. Hydrog. u. marit. Met., Berlin*, **35**, 1907 (396-409 and pl.).

Meissner, O.—Können Luftdruckschwankungen den Erdboden deformieren? *Wetter, Berlin*, **24**, 1907 (258-263).

Meissner, O.—Zur Berechnung des Tagesmittels der Temperatur aus den beiden Extremen. *Wetter, Berlin*, **24**, 1907 (282-286).

Meissner, O.—Der Einfluss der Windrichtung auf die Bewölkung in Potsdam (1894-1900). *Wetter, Berlin*, **25**, 1908 (9-13).

Memorial Notices of Alexander Buchan, M.A., LL.D., F.R.S. By Sir Arthur Mitchell, K.C.B.; J. G. M'Kendrick; Sir John Murray, K.C.B.; R. T. Omond, J. Hann, W. N. Shaw, and H. R. Mill. *J. Scot. Met. Soc., Edinburgh*, **14**, 1907 (101-118).

Meteorological Service in Jamaica. *Symons' Met. Mag., London*, **42**, 1907 (231-232).

Mill, H. R.—The Rainfall of last Year [1907]. *The Times, London*, Jan. 17, 1908.

Mill, H. R.—The Rainfall of 1907. *Symons' Met. Mag., London*, **42**, 1907 (229-230).

Moore, W. L.—The Origin and the Purpose of the Mount Weather Observatory. *Bull. Mount Weather Obs., Washington*, **1**, 1908 (7-11).

Moureaux, T.—Nouvelles déterminations magnétiques dans la région du bassin de Paris. *Ann. Soc. Mét. France, Paris*, **55**, 1907 (188-195).

Nansen, F.—On North Polar Problems. *Geog. J., London*, **30**, 1907 (585-597).

Newbigin, M. I.—The Study of Weather as a Branch of Nature Knowledge. *Scot. Geog. Mag., Edinburgh*, **23**, 1907 (627-648).

Okada, T.—Note on the Diurnal Heat Exchange in a Layer of Snow on the Ground. *Monthly Weather Rev., Washington*, **35**, 1907 (450-452).

Osthoff, H.—Streifenwolken. *Meteor. Zeits., Brunswick*, **24**, 1907 (534-540).

Peppler, W.—Die Schwankungsgebiete des Luftdrucks. *Wetter, Berlin*, **24**, 1907, (248-253).

Quervain, A. de.—Pilotballonanvisierungen in Zurich während der Hochdruckperiode vom 14. bis 25. Januar 1907. *Meteor. Zeits., Brunswick*, **24**, 1907 (540-546).

Reinicke, G.—Die Eisverhältnisse des Winters 1906-07 in den russischen und schwedischen Gewässern der Ostsee. *Ann. d. Hydrog. u. marit. Met., Berlin*, **35**, 1907 (413-426).

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Reinicke, G.—Die Eisverhältnisse des Winters 1906-07 in den dänischen, holländischen, und belgischen Gewässern. *Ann. d. Hydrog. u. marit. Met., Berlin*, **35**, 1907 (426-431).

Richardson, R.—Rain-producing East Winds and their Influence on the Summer of 1907. *J. Scot. Met. Soc., Edinburgh*, **14**, 1907 (141-143).

Richarz, F.—Über Beobachtung des künstlichen Brockengespenster. *Meteor. Zeits., Brunswick*, **25**, 1908 (19-25).

Sadewasser, H.—Über periodische Schwankungen der Windrichtungen. *Wetter, Berlin*, **24**, 1907 (272-279).

Schlenzka, S.—Fesselballonaufstiege für meteorologische Höhenforschung an Bord S.M.S. *Planet. Ann. d. Hydrog. u. marit. Met., Berlin*, **36**, 1908 (63-71).

Schubert, Dr. J.—Die Witterung in Eberswalde im Jahre 1906. *Wetter, Berlin*, **24**, 1907 (241-248).

Schulze, P.—Ludwig Friedrich Kämtz. *Wetter, Berlin*, **25**, 1908 (6-9), 33-36.

Schuster, A.—International Science. *Proc. Roy. Inst., London*, **18**, 1907 (342-363).

Shaw, W. N.—[Obituary Notice of] Sir Richard Strachey, G.C.S.I., F.R.S. *Nature, London*, **77**, 1908 (395-397).

Smith, A. W.—Our present Knowledge regarding the Heat of the Evaporation of Water. *Monthly Weather Rev., Washington*, **35**, 1907 (458-462).

Solvay, E.—De la condensation électrique dans l'atmosphère. *Ciel et Terre, Brussels*, **28**, 1907 (395-409).

Sutton, J. R.—On the Lunar Cloud-period. *Trans. S. African Phil. Soc., Cape Town*, **18**, 1907 (313-320).

Talman, C. F.—Meteorological Stations in Southern Nigeria. *Monthly Weather Rev., Washington*, **35**, 1908 (444-446).

Tamura, S. T.—A Biographical Sketch of Prof. Diro Kitao. *Monthly Weather Rev., Washington*, **35**, 1907 (452-454).

Teisserenc de Bort, L.—Über die Verteilung der Temperatur in der Atmosphäre am nördlichen Polarkreis und in Trappes. *Meteor. Zeits., Brunswick*, **24**, 1907 (498-499).

The International Investigation of the Upper Air. *The Times, London*, Dec. 3, 1907.

Trabert, W.—Die langdauernde Föhnperiode im Oktober 1907 und die Luftdruckverteilung bei Föhn. *Meteor. Zeits., Brunswick*, **25**, 1908 (1-9).

Trowbridge, C. C.—On Atmospheric Currents at very great Altitudes. *Monthly Weather Rev., Washington*, **35**, 1907 (390-396).

Vincent, J.—Le ballon-sonde belge du 25 juillet 1907. *Ciel et Terre, Brussels*, **28**, 1907-8 (495-500).

Vincent, J.—Le grain du 3 août 1905. *Ciel et Terre, Brussels*, **28**, 1907 (445-450 and pl.).

Watts, W. M.—The Spectrum of the Aurora Borealis. *Monthly Weather Rev., Washington*, **35**, 1907 (405-412).

Wedderburn, E. M.—An Experimental Investigation of the Temperature Changes occurring in Fresh-water Lochs. *Proc. Roy. Soc., Edinburgh*, **28**, 1908 (2-20).

Zahn, G. W. v.—Temperaturen des Meereswassers zwischen Vera Cruz und dem Ausgang der Florida-Strasse. *Ann. d. Hydrog. u. marit. Met., Berlin*, **35**, (409-412 and pl.).

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THE ANTICYCLONIC BELT OF THE SOUTHERN HEMISPHERE

BY COLONEL H. E. RAWSON, C.B., R.E., F.R.Met.Soc.

[Read April 15, 1908.]

THREE years spent up and down South Africa during the late war, followed by another period of almost the same length, during which I travelled through the whole of the country from the Cape to the Zambesi, as well as from Durban to Beira, have made me acquainted with the physical features of this vast sub-continent, and enabled me to study the control which the southern anticyclonic belt exercises over its climate. From our President on his return from his visit with the British Association in 1905 the Society received a general description of the country from a meteorologist's point of view.[1] For the visit of the Association Mr. C. M. Stewart, Secretary of the Meteorological Commission, Cape Colony, had specially prepared an article upon the Meteorology of South Africa,[2] and had brought together a great deal of valuable information regarding its rainfall and prevailing winds to assist in the discussion of its climate.

Barometric observations were commenced at the Cape Observatory in April 1841, and at Durban in 1873, and from these monthly means reduced to 32° sea-level and 45° lat. have been compiled and published in the Annual Report for 1905 of the South African Association for the Advancement of Science.[3] In these recent publications, in the annual Reports published by the Observatories of the Cape, Durban, Kimberley, and Johannesburg, with instrumental or eye observations from several hundreds of observers, and in the many valuable isobaric charts which deal with the oceans adjoining South Africa, a very large amount of information regarding South African weather has been collected since 1841

[1] *Quarterly Jour. Roy. Met. Soc.*, July 1906, "South Africa as seen by a Meteorologist in 1905," by H. R. Mill, D.Sc.

[2] *Science in South Africa*, 1905, "The Meteorology of South Africa," by Chas. M. Stewart.

[3] *Report S. A. A. Advancement of Science*, 1906, "The Barometer in South Africa," by R. T. A. Innes, F.R.A.S.

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and is now lying waiting to be analysed. Towards this end I contributed two papers, which were read at the meetings of the South African Association at Kimberley in 1906, and at Durban in 1907.[1] The chief interest is found to centre round the movements of the anticyclonic belt and of its component anticyclonic systems.

Progressive Movements of Permanent Anticyclonic Systems in the Northern Hemisphere.

In July 1898 I brought to the notice of the Society the progressive movements of some of the so-called permanent anticyclonic systems of the northern hemisphere,[2] and I called attention to the fact that such systems followed tracks year after year, which were in some years north and in others south of a mean track. For a series of years the tracks appeared to be displaced in a southerly direction, and in the daily synoptic charts the system would be found dominating an area a little south of that which it occupied at the same season the previous year. This would then be reversed and the tracks would be displaced in a northerly direction. The eleven years from 1881 to 1891 were examined in great detail, almost all available daily and monthly synoptic charts being analysed and the tracks laid down upon a chart. The simplest explanation of such a phenomenon was that a real shifting was taking place in the latitude of the anticyclonic belt itself, and this would certainly control the tracks followed by its component permanent systems. But in spite of the mass of charts that were available, no definite conclusion on this important point could be arrived at, and it appeared hopeless to look for one under the unstable conditions of the northern hemisphere, unless some clue to begin upon could be obtained.

At the Bristol meeting of the British Association in August 1898, Mr. Douglas Archibald referred to van Bebber and Köppen's set of twenty types of weather-systems which had recently attracted so much attention. They were the result of an exhaustive examination of synoptic charts of the northern hemisphere, and it was announced that not only do such types recur annually, but that they exhibit a tendency to succeed or to be associated in some cases with one another. The types were identified as belonging to certain seasons, and it was observed that they would at some seasons precede, and at others would follow, those with which they were most closely associated. In this I found strong support for the views I had just previously advanced regarding the progressive movements of the permanent anticyclonic systems, which in the case of the Europasian systems was from east to west in the first half of the year, and from west to east in the second. In some of the cases it was clear that the types which preceded one another as the systems were moving in one direction, succeeded one another as they moved back on the return journey. But this point was not associated by the authors with any progressive movement on the part of the anticyclonic systems, nor did a reference to their original work throw any light upon the important

[1] *Report S. A. A. Advancement of Science*, 1906, "Anticyclones and their Influence on South African Weather," by Col. H. E. Rawson, F.R.Met.Soc., and "Anticyclones as Aids to Long-Distance Weather Forecasts in South Africa" (not yet published).

[2] *Quart. Jour. Roy. Met. Soc.*, July 1898, "Anticyclonic Systems and their Movements."

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question whether the latitude of the types was ever found to vary. It was evident that the northern anticyclonic belt was too broken to enable anything like an annual change in its general position to be traced, and that for this we must turn to the southern belt, which is under much more stable conditions owing to its being less interrupted by land.

Seasonal Migration of the Southern Anticyclonic Belt.

The seasonal migration of the southern belt is a real displacement northward and southward, with the sun, of the action-centres of the systems which move within it, and not merely a variation in their intensity. All the isobaric charts of the southern hemisphere agree on this point, and the seasonal variations of the winds over the sea and over the land confirm it. It is well seen in the large-scale *Meteorological Charts of the Southern Ocean between Cape of Good Hope and New Zealand*, published by the Meteorological Council in 1899 for each month of the year. They have been prepared from all available logs of vessels for the years 1855 to 1895, and they include the area between lats. 30° and 60° S. and longs. 10° and 180° E. Owing to their not extending farther north than lat. 30°, the action-centres, which lie wholly within them in the months of January and February when the belt is farthest south, have nearly disappeared northwards from them in April, and cannot be traced at all in May. In October the action-centres reappear from the north, and remain visible throughout November and December. Buchan's isobaric charts of the southern hemisphere, representing the mean monthly pressure for the fifteen years 1870-1884, show that these action-centres have reached as far north as lats. 27° and 28° in July and August.

The effect of the migration of the belt upon a single station in the South Indian Ocean can be inferred from the Mauritius records of barometric pressure.

TABLE I.—Barometric Pressure, Mauritius Observatory, Monthly Means, 1875-1900.

Jan.	Feb.	March.	April.	May.	June.
ins.	ins.	ins.	ins.	ins.	ins.
29·751	29·734	29·769	29·818	29·888	29·964
July.	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
ins.	ins.	ins.	ins.	ins.	ins.
30·008	30·010	29·998	29·939	29·878	29·814

The monthly means for the twenty-six years 1875-1900 show that pressure increases steadily from March to July and August, and falls equally steadily from September to February. The greatest mean variations of pressure occur between the months of April, May, and June, and between September and October, and Buchan's isobaric charts of the southern hemisphere for the period 1870-1884 enable us to interpret this as due to the seasonal progressive movements of the permanent system within the belt. It is approaching Mauritius in its journey westwards during the early months of the year, and is receding from it in the later months as it returns eastwards. These movements will not be discussed in what follows, as the object of this paper is to submit certain facts connected with deviations in the belt's latitude; but they must not be overlooked.

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In December 1892 the late Mr. H. C. Russell, F.R.S., the Government Astronomer for New South Wales, brought before the Society[1] the fact that south of lat. 20° S. a series of rapidly moving anticyclonic systems was ever passing across Australia from the westward, following one another with remarkable regularity. The deductions he drew from it did not find favour; but his diagrams of the tracks which the systems followed, and a table of the monthly changes of latitude from March 1888 to July 1892, enable us to trace the migration northward and southward of the belt in which the anticyclones moved. He found that they reached their most northerly latitude in June, and that their mean track was then along lat. 27° 30′. In February their mean track was most southerly, and was along lat. 38° 15′. One of his conclusions, the importance of which will appear hereafter, is given in his own words: "It is our experience that when an anticyclone track is far from the mean, the weather is also far from the mean."

Discrepancies in Isobaric Charts when they have reference to Different Years.

It is a fact well recognised by sailors that the South-east Trades of the South Atlantic are met with much farther north of the equator in some years than in others. Moreover, the various isobaric charts which have been published do not show the action-centre of the South Atlantic anticyclone in the same mean monthly positions when the years to which the charts refer are not the same. If Buchan's charts published in 1869 are compared with those which he made for the period 1870-1884, or if Mohn's charts published in 1879, 1883, and 1903 are compared with those prepared by the Hydrographic Department of the Admiralty from all available logs of vessels for the period 1855-1899, the mean monthly positions of the action-centre will be found to vary very considerably. For example, the following table gives the latitudes between which the centres lie each month, according to Buchan's charts for 1870-1884 and the Admiralty charts for 1855-1899. The latter show no closed centre in July, but pressure extends in a ridge across the Atlantic from east to west with the isobar 30·2 ins. open on the South African side. In September they show two centres not far from one another and of the same intensity, with their axes on the same parallel, a condition which would be looked upon as very exceptional in such daily synoptic charts as those of the North Atlantic for 1882-3.

TABLE II.—Monthly Deviation in Latitude of the South Atlantic Action-Centre.

	1870-1884.		1855-1899.		Isobar.		1870-1884.		1855-1899.		Isobar.
					ins.						ins.
Jan.	Lat.	23½° – 34°	Lat.	22° – 35½°	30·1	July	Lat.	26° – 30°	Lat.	20½° – 34°	30·2
Feb.	,,	26 – 33	,,	25½ – 35	,,	Aug.	,,	25 – 29½	,,	19 – 35	,,
Mar.	,,	24 – 34	,,	22 – 39	,,	Sept.	,,	26 – 30	,,	22 – 34	,,
April	,,	25 – 32	,,	24½ – 38	,,	Oct.	,,	21½ – 34	,,	17 – 37	30·1
May	,,	22 – 33	,,	18 – 34	,,	Nov.	,,	27 – 35	,,	17 – 37	,,
June	,,	24½ – 29	,,	19½ – 31½	30·2	Dec.	,,	21 – 32½	,,	21 – 35	,,

In every month the area covered during the period 1855-1899 is greater than during 1870-1884, which is just what we might expect if

[1] *Quart. Jour. Roy. Met. Soc.* vol. 19, "Moving Anticyclones in the Southern Hemisphere."

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the action-centre was in some years north of its mean seasonal position and in others south of it.

Over South Africa an action-centre is found in some of the charts, but not in all, during the months of June and July; while in some it has become established by May and leaves in August; but in others it does not appear till June, and it then remains on till August. Both sets of charts in the following table are made by Buchan.

TABLE III.—Monthly Deviation in Latitude of the South African Action-Centre.

	1870-1884.	1885-1894.	Isobar. ins.		1870-1884.	1885-1894.	Isobar. ins.
May	Lat. 26°–32½°	No centre	30·1	July	Lat. 27°–31½°	Lat. 28°–32°	30·25
June	,, 26–28½	Lat. 27°–32°	30·2	Aug.	No centre	,, 29–33½	30·175

In this table the charts for the short period 1885-1894 show the action-centre in June and July to be occupying a more southerly position than in the longer period 1870-1884. The date when it first establishes itself over the land is easily identified in the records of the Durban Observatory by the exceptionally large and rapid rise which takes place in the barometric pressure; and the regularity with which it appears is indicative of the wonderfully stable conditions which exist in this part of the southern hemisphere. This is shown in Table IV.

TABLE IV.—Establishment on Land of the South African System.

Year.	1885.	1886.	1887.	1888.	1889.	1890.	1891.
Date	May 20	May 17	May 15	May 31	June 3	June 9	May 29
Intensity	30·445	·452	·543	·424	·618	·617	·644
Year.	**1892.**	**1893.**	**1894.**	**1895.**	**1896.**	**1897.**	**1898.**
Date	May 28	May 9	May 29	May 28	May 29	June 2	May 18
Intensity	30·500	·622	·456	·541	·400	·599	·530
Year.	**1899.**	**1900.**	**1901.**	**1902.**	**1903.**	**1904.**	**1905.**	**1906.**
Date	May 21	May 29	June 4	June 17	June 22	June 19	May 10	May 30
Intensity	30·597	·421	·587	·541	·534	·614	·482	·632

The years 1901-1904 form a notable interruption to the general punctuality of the system, 1903 showing the greatest departure from the mean date. An analysis of the winds, as the system persists over Durban, gives an indication of the position which it is occupying relative to Durban, and it is noteworthy that the years 1904 and 1905 differ from all the rest in being the only ones in which a North-east wind is recorded. In the southern hemisphere such a wind belongs to the northern part of the system, and the inference to be drawn from this, coupled with its late arrival, is that in these years the system was farther south than usual.

The isobaric charts for the month of July published with Mohn's *Grundzüge der Meteorologie* in 1879, 1883, and 1903, differ materially among themselves. In the edition for 1879 the isobar 765 mm., enclosing the Australian action-centre, touches the north coast there, and passing through the north of Madagascar, goes within 10 degrees of the equator as it crosses South Africa. The same isobar in the edition (third) of 1883 lies 6 degrees farther south over Australia, and 10 degrees farther south over South Africa. The importance of this in connection with the present inquiry will appear later on.

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In the *Barometer Manual* published by the Meteorological Council in 1905 isobaric charts are given for the months of January and July, which differ entirely from Mohn's of 1903, or Buchan's for the years 1870-1884. The chart for July shows no action-centre over the Atlantic or South Africa, and the centre over the South Indian Ocean extends 2 degrees of latitude farther north and 4 degrees farther south than shown by Buchan. The Council's chart is compiled from vessels' logs for the years 1855-1899, and this is another instance of the action-centre occupying a much wider area in latitude when the chart has reference to a long period of years.

Testimony of the Winds to Changes in the Latitude of the Anticyclonic Belt.

It might be considered that the discrepancies which have been pointed out could be readily accounted for by the increase in the number of observations and their greater accuracy. But this explanation is insufficient when the percentage frequency of the winds at such observatories as the Cape and Durban are examined and compared for different years. A very real change in prevalence is found to exist, and is so far waiting for an explanation. Mr. C. M. Stewart pointed it out in 1903 as the result of his investigation of the tri-daily observations taken at the Royal Observatory, Cape Town, during 1896-1900.[1] He has compared the percentage frequency of the winds from the eight principal points of the compass during these years with those given by Buchan in the *Challenger* Report for the 18 years 1842-1855, 1862-1865.

TABLE V.—Percentage Frequency of the Winds, Royal Observatory, Cape Town, for 18 Years 1842-1855, 1862-1865 (B), and for 5 Years 1896-1900 (S).

Month.	N.		NE.		E.		SE.		S.		SW.		W.		NW.		Calm.	
	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.
January .	3·2	1·5	0·0	0·3	0·0	0·1	6·4	11·5	**67·8**	**52·9**	3·2	6·7	6·4	4·0	12·9	19·8		3·2
February .	3·6	1·5	0·0	0·0	0·0	0·5	7·1	8·9	**64·3**	**57·8**	3·6	3·4	7·1	3·7	14·3	20·6		3·6
March .	3·2	1·5	0·0	0·2	3·2	0·4	6·4	10·4	**54·9**	**48·4**	3·2	3·5	9·7	4·4	19·3	24·8		6·2
April .	6·7	2·8	0·0	0·6	0·0	0·6	10·0	13·1	**46·7**	**44·9**	6·7	3·3	10·0	3·6	20·0	22·8		8·4
May . .	9·7	6·9	0·0	0·9	0·0	0·3	6·4	12·5	**41·9**	**32·1**	3·2	3·4	9·7	5·1	29·3	31·5		7·3
June . .	16·7	9·4	0·0	0·9	0·0	0·3	3·3	13·6	**30·0**	**26·3**	10·0	3·0	13·3	6·7	26·7	**31·6**		8·2
July . .	16·1	14·3	0·0	0·8	0·0	0·2	3·2	13·1	**38·7**	**17·8**	6·4	2·5	12·9	6·5	22·6	**40·3**		4·5
August .	9·7	10·3	0·0	1·4	0·0	0·2	6·4	11·7	**35·5**	**27·0**	6·4	2·5	16·1	6·1	25·8	**34·3**		6·5
September .	6·7	5·8	0·0	0·3	0·0	0·3	6·7	12·3	**40·0**	**34·4**	6·7	3·3	16·7	10·1	23·3	24·9		8·4
October .	6·4	4·6	0·0	0·0	0·0	0·0	3·2	10·9	**45·2**	**39·1**	6·4	5·6	19·4	12·6	19·4	23·1		4·1
November .	6·7	3·2	0·0	0·4	0·0	0·4	6·7	10·0	**56·7**	**44·3**	3·3	5·1	10·0	7·3	16·7	25·6		3·8
December .	3·2	1·7	0·0	0·0	0·0	0·3	9·7	15·3	**64·5**	**52·5**	3·2	5·7	9·7	5·5	9·7	16·6		2·4
Year . .	7·7	5·3	0·0	0·5	0·3	0·3	6·3	12·0	**48·8**	39·9	5·2	4·2	11·8	6·3	20·0	26·3		5·4

No Returns.

Mr. Stewart points out that these figures lead to very different conclusions regarding the prevalent winds at the Cape to those drawn by Dr. Buchan. Whereas the *Challenger* results indicate that South is the prevailing direction in every month of the year, this table shows decided indications of a "monsoon" influence during 1896-1900, in that during the winter months of June to August the prevailing direction is North-

[1] *Report of the S. A. A. for Advancement of Science*, 1903, p. 63.

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westerly, while it is Southerly during the rest of the year. Both Buchan's and Stewart's figures agree in making the North-west wind more prevalent in the winter than in the summer months, and to be the most frequent wind after the South in every month except December, when the South-east shares it with the North-west. The important point to notice is that Stewart detected a monsoon influence in 1896-1900, which was not traceable in the period analysed by Buchan.

In the annual reports of the Durban Observatory for the 10 years 1885-1894 the percentage frequency of the winds has been calculated each quarter for seven stations within Natal and six stations beyond it. As we have Buchan's monthly isobaric charts of South Africa for these particular 10 years, it is most instructive to follow the seasonal changes in the winds as the belt migrates north and south. It is also evident that in Natal, as well as at the Cape, real changes in prevalence were taking place year by year. In the following table the percentage frequency of the winds at Durban, for the winter half-year April to September, has been compiled from the reports :—

TABLE VI.—Percentage Frequency of the Winds, Durban Observatory, April to September 1885-1894.

	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
Calm .	...	...	...	...	16	15	10	3	2	1
N. .	23	23	21	30	23	23	24	26	22	23
E. .	24	24	26	22	24	26	25	25	25	25
S. .	27	19	28	26	23	24	22	21	24	26
W. .	17	15	24	20	14	12	19	25	27	25

This table shows how regular the winds are during the months April to September except those with a Westerly component, whose increased frequency in 1892, 1893, and 1894 marked these years out for special examination. Observations of the winds are recorded twice a day, at 9 a.m. and 3 p.m., at the Observatory, and on consulting the daily records it became apparent that these years were exceptional, not only for the number of entries of a NW., NNW., or WNW. wind during the months April to September, but also throughout the year. There were not many for 3 p.m., and the following table was consequently compiled for 9 a.m. only :—

TABLE VII.—Records of NW., NNW., and WNW. Winds, Durban Observatory, 1890-1905.

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.
Jan.	...	1	4	3	...	...	...	...	...	...	...	...	...	...	...	...
Feb.	1	1	8	4	1	...	...	...	...	...	...	...	...	...	...	...
Mar.	2	2	9	4	3	...	1	...	...	1	...	...	...	...	...	...
April	1	4	12	3	8	...	2	2	2	2	1	1	4	3	1	1
May	4	13	12	10	11	8	7	8	4	8	2	9	7	3	6	3
June	7	11	24	14	15	11	10	10	15	7	5	12	8	11	6	10
July	9	12	15	10	13	11	10	11	7	4	17	12	10	5	8	8
Aug.	3	10	13	12	10	8	5	1	4	...	6	1	4	1	5	1
Sept.	...	5	9	2	1	3	2	...	...	...	1	...	...	...	1	...
Oct.	...	2	2	1	...	2	1	...	...	...	...	...	...	...	...	...
Nov.	...	...	3	3	...	...	...	...	...	...	...	...	1	...	...	...
Dec.	1	1	3	...	...	...	...	...	...	...	...	...	1	...	...	...

In this table the years 1892, 1893, and 1894 stand out above all the others in the number of records from April to September, while

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1892 and 1893 are exceptional during the other months of the year as well. In following up this matter in order to try and ascertain its significance it was observed that, in almost every year from 1895 to 1905, one of the earliest appearances of a North-west wind was associated with the same weather characteristics, viz., a barometer reading of over 30·2 ins. and well-defined anticyclonic indications, calm or very light winds, and a clear sky. The same type could be equally easily detected in the years 1890-1894, but it occurred in March or April and not necessarily on the first appearance of the North-west wind.

The following table gives the records of the first arrival of the North-west wind, April 24-29, 1905, and they are typical of all the rest :—

TABLE VIII.—Anticyclonic Type, with NW. Wind, Durban Observatory, April 24-29, 1905.

	Barometer.		Moisture.	Rainfall.	Wind.		Amount of Cloud.		Sky.	
April.	9 a.m. ins.	3 p.m. ins.	Grains. cub. ft.		9 a.m.	3 p.m.	9 a.m.	3 p.m.	9 a.m.	3 p.m.
24	30·089	30·085	6·3	...	Calm	S. v. light	0	3	Clear	Stratus
25	30·228	30·182	6·2	...	NW. light	Calm	0	0	Clear	Clear
26	30·299	30·260	6·0	...	Calm	NE. moderate	0	0	Clear	Clear
27	30·302	30·222	6·2	...	N. v. light	NE. light	0	0	Clear	Clear
28	30·231	30·146	6·2	...	N. v. light	NE. moderate	0	0	Clear	Clear
29	30·159	30·101	6·7	...	Calm	NE. moderate	0	0	Clear	Clear

This is distinctly an anticyclonic type. On application to the Johannesburg Observatory, which was opened in 1905, I obtained from the Director details of the barometric pressure prevailing during this period over South Africa at all stations from Tomba (lat. 15° S.) to Cape Town.[1] The isobaric chart which was specially prepared for April 25 showed an extensive anticyclone lying from east to west across South Africa with an open side towards the east. The highest pressure of the anticyclonic belt had spread from the east westwards in the form of a ridge, *and Durban lay on the southern edge.* The advent of North-west winds at Durban, associated with high pressure, marks the arrival of the anticyclonic belt in the course of its annual migration northwards, and I infer that when this wind is found prevailing in exceptional months the anticyclonic belt is in an exceptional position. In January and December 1891 the North-west wind is recorded with a barometric pressure of 30·253 ins. and 30·346 ins. respectively, and these rare occurrences are followed in the two succeeding years by the exceptionally numerous records of North-west winds which are given in Table VII. The inference I have drawn is that in either 1892 or 1893 the belt was in an extreme northerly position. It will be useful at this point to summarise the arguments that have been used, and the results which have so far been obtained.

Summary.

An examination of the daily synoptic charts of the northern hemisphere led to the conclusion that some of the permanent anticyclonic

[1] I wish to acknowledge the great assistance I have received from Mr. Innes, Director of the Transvaal Meteorological Department; Mr. Nevill, Natal Government Astronomer; Mr. Sutton, Kimberley Observatory; and the members of their Staff. They have given me access to all their records, and afforded me all information which would throw light on the points raised in this paper.

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systems had a progressive seasonal movement which did not take place along the same latitude each year, but was in some years north and in others south of a mean latitude. This was noticeable in the years 1881-1891, and was capable of easy explanation if the belt itself in which they moved shifted its latitude from year to year in addition to migrating north and south with the sun. On analysing the isobaric charts of the southern hemisphere the seasonal migration of the anticyclonic belt is found to be accompanied by a real displacement of the action-centres within it to the northward and to the southward. But when the charts are compared great discrepancies are found to exist in the positions of the centres, if the years to which they refer are not the same. Moreover, when they are prepared for a long period of years the action-centres show a much wider displacement from a mean latitude than for a short period. In one case charts which were published in 1879 were considerably modified in 1883, the area of maximum pressure within the belt being shown farther south. These discrepancies cannot be accounted for solely by an increase in data or more reliable methods of observation, for important changes in the percentage frequency of the winds recorded at the observatories have taken place. At the Cape a "monsoon" influence, associated with the winter months of the years 1896-1900, in connection with the North-west wind, is found to exist, which was not traceable in the years 1842-1855, 1862-1865. At Durban a decided increase in the percentage frequency of winds with a Westerly component in winter months of the years 1892 and 1893 is traced to an increased prevalence of the same North-west wind, and it is found to prevail in an exceptional manner during the summer months also. This wind is proved to indicate the arrival at Durban of the south side of the anticyclonic belt, and the inference is drawn accordingly that during 1892 and 1893, when it prevailed throughout both summer and winter months, the south side of the belt was much farther north than usual.

Meteorological Changes in relation to the Belt's Latitude.

The prevalence of winds with a Westerly component is in accordance with all that we know about the south side of the belt as it lies over the oceans. As long ago as Maury's time it was recognised that South-east winds blew out of the north side of the belt of calms, while on the south side "the winds with Westing in them become the prevailing winds, and between the parallels of 35° and 40° S. the North-west and South-west winds contend with equal power for the mastery." In the monthly charts published by the Meteorological Council in 1882, *Charts for Ocean District adjacent to Cape of Good Hope*, which include the area 10° E. to 40° E. long. and 30° S. to 50° S. lat., we see how completely Westerly winds prevail below lat. 40° S. from January to March, and how they are found farther and farther north till they reach their farthest limit in July. The letterpress on the charts says, "Westerly and Easterly winds alternate near the land. In summer Easterly winds, in winter Westerly winds prevail. Southerly winds (SW. to SE.) prevail throughout the year in the north-west corner of the district" (*i.e.* off the Cape), "but they extend farther south in summer than in winter." From this

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description of the seasonal variations of the wind we can form a picture of the action-centres of the anticyclonic belt—the calm zone of old days—"vibrating up and down," as Maury expressed it, "with the trade-wind zone, partaking of its motion and following the declination of the sun." If the anticyclonic belt was farther north than usual during the period 1896-1900, the zone of counter-trades with its prevailing North-west wind would reach as far north in June, July, and August as the Cape Peninsula, and we should have in this fact an easy explanation of the increased prevalence Stewart detected in those years.

It is a direct consequence of the anticyclonic belt coming south and lying over the Cape Peninsula (lat. 34° S.), with its Atlantic system not far from the coast, that the Cape has its dry season from September to April. The belt being south of Durban (lat. 30° S.), Natal, Orange River Colony, and the Transvaal have their wet season in these months. When the belt goes north and an action-centre becomes established on land the dry season of these colonies, which begins in May and lasts till August, reaches its maximum, while the wet season prevails at the Cape. This difference in the dry and wet seasons of the two sides of South Africa is one of the most striking characteristics of its climate. The explanation hitherto given has ascribed it almost entirely to the winds, and has overlooked the systems which give rise to the winds. I have already dealt with this in the paper that has been referred to, "Anticyclones and their Influence on South African Weather," and I need not pursue the subject here.

Capt. Campbell Hepworth, in "The Tracks of Ocean Wind Systems in transit over Australasia,"[1] notices that the centres of the cyclonic systems travelled eastward across the South Indian Ocean "on a more polar path during summer months than in the winter." The four diagrams of the tracks of high- and low-pressure systems during the months November 1890 to March 1891, and May to September 1891, which accompany his paper, show very conclusively that the tracks of the cyclonic systems are kept to the southward of the anticyclonic tracks, and migrate north and south with them. In the Admiralty manual, *Africa Pilot*, 1905, for the area lying between long. 10° E. and 40° E., lat. 30° S. and 50° S., it is stated that on lat. 40° S. and southwards the probability of meeting gales is in January 8 per cent, April 10 per cent, July 14 per cent, October 9 per cent. Farther northwards near the South African coast, it is in January 6 per cent, April 6 per cent, July 13 per cent, October 10 per cent. We should therefore expect that in years when the anticyclonic belt was sufficiently north of Durban to admit more low-pressure systems than usual, the rainfall there should be heavier. We have seen reasons for supposing that 1892 and 1893 were two such years, and the following table gives the rainfall each year from 1885 to 1905.

The year 1893 was therefore remarkable for the phenomenal rainfall of 71·27 ins., or 31·90 ins. above the average for twenty-one years. In discussing the meteorology of the year, the Natal Government Astronomer pointed out that the actual rainfall during the rainy season, September to April 1893-4, was 51·95 ins., or 18·85 ins. above the average of the twenty previous years; and that from September to April 1892-3 it was

[1] *Quart. Jour. Roy. Met. Soc.*, October 1892, p. 34.

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46·96 ins., or 13·86 ins. above the average. To find anything approaching such a rainfall it was necessary to go back to the years 1874 and 1875. He concludes as follows: "All things considered, it is probable

TABLE IX.—Rainfall in Inches at Durban Observatory, 1885-1905.

Year	1885.	1886.	1887.	1888.	1889.	1890.	1891.	
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	
Rainfall	34·48	31·79	31·87	37·74	29·54	32·91	45·45	
Year	1892.	1893.	1894.	1895.	1896.	1897.	1898.	
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	
Rainfall	38·37	71·27	37·27	51·50	39·63	34·39	42·48	
Year	1899.	1900.	1901.	1902.	1903.	1904.	1905.	Mean.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
Rainfall	28·75	27·24	55·54	41·18	35·66	34·72	44·95	39·37

that the excessive rainfall of the seasons 1892-93 and 1893-94 may have had its origin in the abnormal disturbances which appear to have taken place in the Antarctic regions during the years 1891-93, which resulted in great masses of ice having been driven north as far as 40° S. lat. *The probable effect of this would be to throw the northern border of the great southern rain-belt into close proximity to the south-east coast of Africa, so that outlying portions might easily have impinged thereupon, and then given rise to this heavy rainfall.*" He returns to the same subject in his report for 1896. "The same meteorological conditions are now prevalent as in the years 1892-93, and it appears probable that the same causes have been at work. . . . *All this points to the close approach of the great southern cloud-belt, which seems to have shifted far further north than its usual range.* In the year 1893 the same thing occurred, owing to some great disturbance in the Antarctic having broken up the icefields, and driven great masses of ice far towards the north." Again in the report for 1897 he writes: "Unusually heavy rainstorms appear to have occurred on the south-east coast, as at Port Elizabeth and St. John's, *but they have not reached so far north as Natal.* It is true that, as anticipated, the great southern rain-belt has been forced far north of its usual limits, but in a direction too far east to impinge on the coast of Natal; hence the absence of any great rainstorms similar to those of the year 1893, such as might otherwise have been expected." The portions I have italicised strongly support the hypothesis that the southern anticyclonic belt was far north in 1892-3, and that after those years it was returning south. In 1897 it was preventing the rain-belt from reaching so far north as Natal, but permitting it to impinge upon and bring heavy rainstorms to stations farther south.

Variations of Barometric Pressure in relation to the Belt's Latitude.

It is quite in conformity with our view of the northerly position of the anticyclonic belt in 1892 and 1893 that the annual mean pressure for the former year at Durban was the absolute lowest of the whole series 1873-1905, and for the latter year the ninth lowest.

But if the belt shifted its latitude and in doing so controlled the tracks of the anticyclonic systems which are known to be ever travelling from west to east within it, besides determining the latitude of the more permanent action-centres, the passage of the belt north and south must have left its trace upon the mean barometric pressure of the stations it

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passed over. All the inquiries I made from stations south of lat. 26° went to prove that after 1894-5 there was a distinct change in the weather they experienced: it was more anticyclonic. In Natal it culminated in the year 1899. In a discussion regarding the rainfall of the Indo-oceanic region during 1895-1902, which appeared in *Nature* at the end of 1904 and beginning of 1905, Sir John Eliot referred to the eastern half of South Africa as having had heavier rain than usual during 1892-1894, while it was "steadily in defect during the five years 1895-1899, and was specially deficient in 1897 and 1899." Mr. J. R. Sutton, of the Kimberley Observatory, in the same correspondence stated that the percentage of rainfall during 1899 had been 64 per cent in the eastern district of the South African coast, and 87 per cent in Natal. In Table IX. the rainfall at Durban appears as nearly 11 ins. below the average, and in the report for the year it is said to be the lowest recorded at Durban since 1878.

The mean annual pressure for the year 1899 at Durban was also phenomenally high. And here we come to the first of a series of coincidences, if they are to be regarded as such, in connection with the hypothesis that the belt reached a northerly position in 1892 and 1893, and then returned southwards. The Durban observations show that six years before 1893 and six years after 1893 the two highest annual means occurred which have ever been recorded. The following are the mean monthly readings for the years 1887 and 1899 which are given in *The Barometer of South Africa* to represent the barometric pressure at Durban :—

TABLE X.—Mean Monthly Readings of Barometer at 9 A.M., Durban Observatory.

Year.	Jan.	Feb.	March.	April.	May.	June.	
	ins.	ins.	ins.	ins.	ins.	ins.	
1887	29·988	30·023	30·077	30·145[5]	30·207[2]	30·313[2]	
1899	29·950	29·975	·054	·148[4]	**·276**[1]	**·328**[1]	
1873-1905	29·973	30·005	·048	·096	·135	·223	
Year.	**July.**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Mean.**
	ins.	ins.	ins.	ins.	ins.	ins.	ins.
1887	30·222	30·154	**30·273**[1]	30·102	**30·093**[1]	29·997	**30·133**[1]
1899	·253	·156	·186[3]	·067	·078[2]	·983	·121[2]
1873-1905	·235	·195	·158	·093	·025	·992	·098

Note.—1, 2, 3, 4, 5, 8 are the highest, second, third, etc., highest of the series 1873-1905.

The mean annual reading for 1887 was thus the highest, and for 1899 the second highest ever recorded. The mean monthly readings for May and June 1899 were the highest, and for May and June 1887 the second highest; for April 1899 the fourth, and for April 1887 the fifth highest; for September 1887 the highest, and for September 1899 the eighth highest; for November 1887 the highest, and for November 1899 the third highest.[1] The close resemblances running through the individual months, as well as in the two years as a whole, can only be accounted for by the hypothesis that the anticyclonic belt occupied the same relative position to Durban in both years, and the very high pressure which

[1] It must be remembered that the range of the barometer in these latitudes is very small. The readings are only taken at 9 a.m. and 3 p.m. at Durban, and the greatest range that has been recorded since the Observatory was opened amounts to 1·452 ins. The annual mean for 1887, as determined by the readings taken at 9 a.m. and 3 p.m., is 30·133 ins., and for 1899, 30·129 ins., without being reduced to gravity of lat. 45° as in Table X.

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prevailed indicates that its mean position for the year must have been very close to the latitude of Durban. Table IX. shows that 1887, like 1899, was deficient in rainfall, amounting to almost 8 inches, and the report for the year states that this was the case throughout the colony. It also appears from the reports that from 1886 to 1889 the number of thunderstorms showed a great decrease at all the large towns in Natal, in marked contrast to the large number in 1890 and following years. The point was specially commented upon by the Government Astronomer.

From these facts I draw the first definite conclusion regarding the position of the anticyclonic belt in any particular years, viz., that in 1887 and 1899, during the months of April and September, its central axis lay approximately along lat. 30° across South Africa, and that it migrated north and south of this position with the sun; further, that in 1893 the central axis reached its farthest northerly point.

Determination of the Extreme and Mean Positions of the Belt.

It is important to ascertain whether the change in the belt's latitude is progressive and cyclical in its character, and in what year the most southerly position was reached. Seamen have long held that the Belt of Calms lay between lat. 30° and 35° S. and migrated north and south of this with the sun, but South African meteorologists have, as a rule, given little attention to the existence of the belt as it crosses the land. In the paper which was specially prepared for the British Association upon the meteorology of the country the word "anticyclone" occurs very seldom, if at all. There is a notable exception, however, to this in the annual reports of Mr. Nevill, the Natal Government Astronomer, from whose Durban observations I have drawn so much. In 1893, when discussing the phenomenal rainfall of the year, he remarked: "Natal is on the border of a great southern anticyclonic belt, and it would appear that it is the position and condition of this belt which mainly regulates the climate of Natal. . . . As soon as the laws governing the motion and physical condition of this belt have been approximately determined, so that from a knowledge of its character in the past year there can be ascertained its probable nature in the coming year, then this knowledge can be applied to predicting the probable character of the coming season in the different districts of Natal." His reports show that the idea of a moving zone, which was sometimes much farther north than at others, is often in his mind, and that he had hopes that something would be found out regarding its movements, as the conditions governing the variations in weather over the southern hemisphere appeared to be much simpler, and less liable to extraneous disturbances, than those regulating the variations in the northern hemisphere. I shall return to this again.

But though there is no analysis of the belt's movements to help us, some valuable records of droughts and exceptional rainfalls have been compiled and discussed. In 1889, Mr. D. E. Hutchins, the Conservator of Forests, Cape Colony, who has done so much to assist in tracing any connection that there may be between the meteorology of South Africa and of India, published his *Cycles of Drought and Good Seasons in South Africa*, which supports in a very remarkable way the view that the belt's movements are not only progressive, but cyclical in their character. The

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chief object of his inquiry was to test Meldrum's Cycle and the Sunspot theory, by analysing all the special droughts and rainfalls which he could find recorded. He was able to find one which went back as far as 1622. But after endeavouring to fit them in he was unable to find a place for certain exceptional rainfalls in the Cape Peninsula even by making allowances for "Irregular Mitigation" and "Cyclical Mitigation" in their cases. He was forced to adopt another cycle altogether, to which he gave the name of the "Storm Cycle," with a period of 9·5 years, or by going back to 1622 the more accurate one of 9·43 years. The rainfall curve which he gives for the Cape Observatory for the years 1841 to 1888 is, in his opinion, convincing proof of the existence of a 9·5-year cycle over the south-western districts of South Africa, which does not extend, however, to Natal and the east. He discusses the rainfall at several stations along the latitude of about 33° 30′, and detects the storm cycle in them readily; but when he comes to Aliwal North, lat. 31°, he remarks that this station exhibits serious anomalies. "The eastern rainfall," he writes, "differs primarily from the Atlantic rainfall in being influenced by the storm cycle only in the matter of wind." He finds that at eastern stations the cyclical phenomena are materially different, and show little or no connection with western stations. Grahamstown marks the limit to which the cyclical rainfall extended eastwards, and I would call attention to the abrupt trend to the north-east which the coast line takes not far from this station.

The storm-cycle years of the south-west district of South Africa are of great importance to us at this point of our inquiry. Mr. Hutchins states them to be: 1850, 1859, 1869, 1878, and 1888. All these years stand out prominently on the rainfall curve as years of maximum rainfall. I will only give details of the two periods 1853-1859 and 1872-1878 as typical of the whole series.

TABLE XI.—Rainfall at Royal Observatory, Cape Town, 1853-1859 and 1872-1878.

Year.	1853.	1854.	1855.	1856.	1857.	1858.	1859.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.
Rainfall	21·23	20·06	24·58	19·48	22·04	24·28	36·73
Year.	1872.	1873.	1874.	1875.	1876.	1877.	1878.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.
Rainfall	29·33	23·70	26·20	25·72	26·65	35·57	41·03

In this table the corresponding years of the 19-year period are brought together, and the fluctuations in the rainfall, as it rises to a maximum in the storm-cycle years 1859 and 1878, are well seen. The storm-cycle year 1888 was one of exceptionally heavy rainfall, and, with 1889, is distinguished by Buchan, in his analysis of the Cape rainfall from 1841 to 1894, as being in a great measure the cause of the pentade 1886-1890 being one of the two wettest pentades of the series.

But the conclusion that has been arrived at is, that in 1887 the anticyclonic belt was over lat. 30° and was going north, so that in 1888 it lay just to the north of this latitude. In 1899 it was once more over lat. 30° returning south, and consequently in 1898 it was in the same position as it was in 1888. If the movement of the belt is progressive, a cycle of 9·5 years will exactly coincide with and explain the

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belt's northerly position in 1893; and it will travel to its most southerly position, and return to that occupied in 1888 and 1898 in another 9·5 years. *The storm-cycle years detected by Mr. Hutchins are those in which the belt occupies its mean cyclical position just north of lat.* 30°. But if, when it is in this position, stations near lat. 34° S. experience great rainstorms, it would be only natural that, when it is far north, southern stations occupying the same relative position should also have the same great rainstorms. The phenomenal rain experienced by Durban in 1893 is an indication that the belt was in that year as far north of Durban as it was north of the Cape Observatory in the storm-cycle years. Durban's storm-cycle years should therefore be 1893, and years at intervals of 19 years before and after it. The following table gives the actual rainfall experienced in such years at Durban as far back as records exist:—

TABLE XII.—PHENOMENAL RAINFALL AT DURBAN OBSERVATORY.

Year.	1855.	1874.	1893.	Mean for 21 years.
	ins.	ins.	ins.	ins.
Rainfall	82·82	55·06	71·27	39·37

The exceptional rainfall of 1874 and 1893 has already been referred to, and as regards that of 1855 Mr. Hutchins says that it was heavy all over the eastern part of South Africa as well as over Durban, where it was heaviest. These years may therefore be correctly described as Durban's storm-cycle years, and the eastern rainfall and the western are equally controlled by the position of the anticyclonic belt. Just as in 1892 the annual mean pressure at Durban was the lowest ever recorded, so in 1873 it was the next lowest. For 1854 we have no records.

The clue given by the storm-cycle years discovered by Mr. Hutchins has led to the second definite conclusion regarding the annual changes in the belt's latitude. In 1888 and in each alternate 9th and 10th year before it, the belt lay a little north of lat. 30°, in its mean cyclical position; and north of this, good reasons exist for believing that its entire oscillation up and down was a regular progressive movement. If this was continued south of the mean position and was of a similar character, it ought to be possible to determine the position it occupied in 1883 or 1884, when, according to the cycle of 9·5 years, it was in its most southerly position. From this the extreme range of the belt might be obtained approximately.

Amongst the droughts of South Africa recorded by Mr. Hutchins, that of 1882-1885 over the south-western districts and the Cape Peninsula holds a prominent place. He writes of it, "Thus the drought (ending with 1885) is one of the severest that have occurred in recent years in South Africa . . . it lasted for the considerable length of 4 years . . . it broke up in the spring (at the end) of 1885"; and he records that in 1884 there was a general dying out of the black ironwood trees in the district. As far north as King William's Town (lat. 33°) he found that the drought broke up by the end of 1885; but he specially mentions that at Aliwal North, which is on the same meridian, but in lat. 31°, it did not break up till 1887. This is the year when the belt had reached lat. 30° and was

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going north, and we should therefore expect the drought to continue at lat. 31° until the belt had passed. The mean barometric pressure for the year 1884 at the Cape Observatory was exceptionally high, being the fifth highest of the series 1841-1905, whereas that for 1883 was about the mean. We therefore conclude that the belt was in its most southerly position, not far from the latitude of the Cape Observatory (lat. 34°), in 1884, and that it took the same length of time to rise from that latitude to its mean position in 1888 as it took to reach its most northerly position in 1893, viz., 4 to 5 years.

This can easily be put to the test, for in 1850 and 1869 the belt was in the same mean cyclical position as in 1888, and 4 to 5 years previous to these dates it would be occupying the same southerly position relative to the Cape Observatory and the Cape Peninsula as in 1884. We should therefore expect to find that similar meteorological conditions prevailed. From Buchan's analysis of the Cape rainfall from 1841 to 1894 it is seen that he points out the years 1864, 1865, and 1866 as the three driest consecutive years of the 54, the rainfall for 1865 being over 10 inches below the mean, while Mr. Hutchins gives the whole period from 1863 to 1868 as one of drought over this district. Similarly the rainfall of 1845 is given by Buchan as 8 inches below the mean, and Mr. Hutchins records a drought round 1845 which he describes as most intense in 1844. Livingstone in his *Travels* also mentions this drought as most severe, and lasting from 1842 to 1846. The barometric pressure for the years 1845, 1865, and 1884 is as follows:—

TABLE XIII.—Barometric Pressure, Royal Observatory, Cape Town, Monthly Means, 1845, 1865, and 1884.

Year.	Jan.	Feb.	March.	April.	May.	June.
	ins.	ins.	ins.	ins.	ins.	ins.
1845	29·951	29·933	30·007[2]	30·055[6]	30·082	**30·230**[1]
1865	·963[5]	·927	29·934	·022	·054	·208[3]
1884	·945	·917	·963	29·984	·054	·207[4]
1841-1900	·923	·922	·956	30·013	·057	·128

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.
1845	30·162	30·184[4]	30·050	30·054	30·011	29·964	**30·057**[1]
1865	·121	·120	·062	29·991	**·061**[1]	·925	·032
1884	·224[3]	·143	·107	30·035	·018[10]	·953	·046[5]
1841-1900	·157	·124	·096	·037	29·989	·948	·029

Note.—1, 2, 3, 4, 5, 6, 10 are the highest, second, third, etc., highest of the series 1841-1905.

From this table we learn that some exceptionally high pressures occurred in each of the years, those for the month of June being the first, the third, and the fourth highest for the 65 years; and the annual means for 1845 and 1884 the highest and the fifth highest respectively. If the inquiry is extended to 1903, the next year in which the belt reaches its most southerly position, exactly the same anticyclonic conditions are found to prevail at the Cape. In the Meteorological Commission's *Report* for this year it is described as "one of exceptionally severe drought lasting throughout the year, unusually low mean temperatures, long-continued and severe frosts, and a fairly high percentage of cloud." The mean annual pressure was the ninth highest, and the means for February, March, and November, the first, seventh, and fourth highest of the 65 years.

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All these facts support the view that in 1884 the belt lay approximately over lat. 34°, and as it was found in 1888 lying a little to the north of lat. 30° its change of latitude amounted to about $4\frac{1}{2}°$, or 1° of latitude a year. Its range in 9·5 years would therefore be $9\frac{1}{2}°$, and in 1893, when it reached its extreme northerly position, it would lie approximately over lat. $24\frac{1}{2}°$. In Buchan's isobaric chart for July, which he published in 1869, the action-centre is shown centrally placed over lat. 24°, and this is the most northerly position I have found it to occupy in any of the charts.[1]

The following table gives the years in which the belt reached its extreme northerly and southerly and mean positions since barometric records were commenced in South Africa, and it summarises the analysis that has been made of its cyclical changes of latitude.

TABLE XIV.—Cyclical Changes of the Belt's Latitude and Years of reaching its Extreme and Mean Positions.

Anticyclonic Belt.	Latitude.	Years.	Interval.
Extreme Northerly Position	$24\frac{1}{2}°$ S.	1855, 1874, 1893	19 years
Mean Position . . .	$29\frac{1}{2}°$ S.	1850, 1859, 1869, 1878, 1888, 1898	9·5 ,,
Extreme Southerly Position	34° S.	1845, 1865, 1884, 1903	19 ,,

This table should only be regarded as a first attempt to determine the positions of the anticyclonic belt as it performs its double oscillation in a period of 19 years. But it explains in a simple manner and correlates all the principal meteorological features which have been referred to in this inquiry.

1. Isobaric charts must necessarily differ when they do not refer to the same years. Those which include a long period, such as from 1855 to 1899, are giving, the table shows us, the mean pressure resulting from two complete oscillations and a half of the belt, and the action-centres will cover a wide area from north to south, as Table II. showed to be the case. In Table III. the centres in June and July were found occupying a more southerly mean position in the period 1885-1894 than in 1870-1884. We now see that during the latter period the belt travelled twice over the latitudes north of its mean position and only once over those south of it, whereas during the 10 years 1885-1894 the belt was making practically one journey from south to north. The change in the latitude of the belt which Mohn's charts indicate to have taken place between 1879 and 1883 is in accordance with Table XIV., which shows that the belt was moving south from 1878 to 1884.

2. The examination of the winds at the Cape Observatory during the years 1896-1900, as compared with those for 1842-1855, 1862-1865, led to the detection of an increased prevalence of North-west wind in the former years, and of a monsoon influence which was not traceable in the latter. Table XIV. shows that from 1896 to 1900 the belt was always much to the north of the Cape latitude, and that the North-west wind of its southern edge would necessarily prevail to a great extent in the months of June-August. During the periods 1842-1855, 1862-1865, the

[1] In Clement Ley's *Cloudland* (published 1894) the isobaric chart shows the action-centre in a similar northerly position. His isobaric charts of 1879 and 1894 deserve more consideration than they have received.

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belt was for 12 years out of the 18 south of its mean latitude, and this would lead to the monsoon influence being masked.

At the Durban Observatory the great prevalence of North-west wind in 1892-1894 and the decrease in 1902-1904 find a ready explanation in Table XIV., which shows that the belt was in its extreme northerly position in 1893, and in its extreme southerly position in 1903. The lateness of the establishment of the South African system on land in 1901-1904, which is pointed out in Table IV., and the occurrence of North-easterly wind at the same time, are just what would result from the belt occupying its extreme southerly position in those years. In connection with this point it is significant that in the *Meteorological Charts of the Southern Ocean between Cape of Good Hope and New Zealand*, which cover the long period from 1855 to 1895 and include two complete double oscillations of the belt, an action-centre within an isobar of 30·3 ins. is found in July south of lat. 30° and to the south-east of Natal. Nothing similar appears on any charts covering a short period. As the belt persists for some time over the same area during the end of its oscillation, it is only to be expected that charts for a long period should show a centre in such a position.

3. The important change in the latitude of the southern cloud-belt during the years 1893 to 1897, which was detected by the Natal Government Astronomer to have shifted far farther north than its usual range, is now seen to be directly connected with a similar shifting of the anticyclonic belt. This leads to the inference that the whole of the zones have a cyclical progressive movement similar to that of the belt.

4. The exceptionally heavy rainfall and the severe droughts which have occurred both in the south-western and in the eastern districts of South Africa are all found to be related to the position of the belt at the time, and the necessity for considering the eastern rainfall to be primarily different from the Atlantic rainfall is shown by Table XIV. to have no foundation in fact. The cause of exceptional barometric pressure is also traceable to the cyclical progressive movement of the belt.

The hypothesis that the belt is always changing its latitude appears to be the clue to South African meteorology, and on turning to Mr. Russell's conclusions regarding that of Australia there seems to be a cyclical variation of the belt there also, which corresponds very closely with that which is given in Table XIV. He was led to advance the theory that there is a general periodic recurrence of seasons every 19 years, and that during every cycle of 19 years there are two periods of good seasons, and two periods of bad seasons, due to droughts, besides minor fluctuations. The Natal Government Astronomer, in his report for 1896, has analysed and reduced to tabular form the seasons experienced in Australia from 1872 to 1896, and has compared them with those of Natal with a view to ascertaining whether they are the same for both districts. Good seasons are those in which good rains fell, and bad seasons those in which droughts were experienced, and the comparison is so confirmatory of the views that have been advanced in this paper, that I reproduce the table as he gives it, and the conclusions which he draws from it in his own words. I have already referred to his frequent mentions of, and belief in, the shiftings of the anticyclonic

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and cloud belts over Natal. In the following table the rainfall is that of the whole wet season, from about the end of August to the middle of May.

TABLE XV.—Periodic Recurrence of Seasons in Australia and Natal.

Season.	Character in Australia. According to Theory.		Character in Australia. As Experienced.	As Experienced in Natal. Rainfall. ins.	As Experienced in Natal. Character.	Remarks.
1872-3	Good		Good	47·39	Good	
1873-4	Good		Good	50·53	Good	Favourable
1874-5	Drought	Drought	Bad	49·92	Good	
1875-6	Drought		Bad	53·02	Good	
1876-7	Drought		Bad	33·15	Bad	
1877-8	Average	Favourable	Good	34·07	Bad	Drought
1878-9	Good		Good	34·05	Bad	
1879-80	Average		Bad	47·32	Good	
1880-1	Drought		Bad	36·77	Average	
1881-2	Good		Good	34·64	Bad	
1882-3	Average		Good	41·73	Average	
1883-4	Drought		Bad	39·57	Average	
1884-5	Drought	Drought	Bad	39·10	Average	
1885-6	Drought		Bad	39·78[1]	Average	
1886-7	Drought		Good	28·42	Bad	
1887-8	Average		Bad	34·32	Bad	Drought
1888-9	Good		Good	34·26	Bad	
1889-90	Good		Good	28·83	Bad	
1890-1	Average	Favourable	Good	42·38	Average	
1891-2	Average		Bad	30·85	Bad	
1892-3	Good		Bad	55·98	Good	
1893-4	Average		Good	56·60	Good	Favourable
1894-5	Drought	Drought	Bad	54·81	Good	
1895-6	Drought		Bad	36·17	Average	

[1] An arithmetical error has been corrected.

The Natal Astronomer writes with regard to this table: "It will be seen that the character of the seasons as experienced in Australia accords fairly well with the theory . . . but that the Natal seasons are by no means in accord with those experienced in Australia, and the theory as set forth does not correctly indicate the value of the Natal seasons. If there be any connection between the characters of the Natal and Australian seasons such as must be the case if the theory be correct, it must be *that there is an interval of one or more years between the corresponding phases of the cycle as manifested in Natal and Australia.* On careful comparison it will be seen that there is some ground for such an idea, and that the Natal cycle follows the Australian cycle at an interval of two or three years. Thus the minor Australian drought of 1874-1877 was followed two years later by the Natal drought of 1876-1879; and the major Australian drought of 1883-1887 was followed three years later by the Natal drought of 1886-1890." The words I have italicised direct our attention to the relative latitude of Natal to the extreme positions of the belt in 1874-1877 and 1883-1887, when Australia experienced its droughts. If we refer to Table XIV. we see that all the droughts in Australia correspond with the period when the belt was at the extreme end of its oscillations, and Mr. Russell's theory probably rose out of the existence of the belt's double oscillation over Australia. The droughts in Natal, as we have already seen, occurred as the belt passed to and fro over the country. In the Natal report for 1893 the Government Astronomer, when discussing

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Mr. Russell's views regarding a 19-year cycle, having two periods of good and bad seasons, refers to the southern anticyclonic belt and writes: "As the position of this belt probably is cyclic in character, with a period approaching 9 years or a multiple thereof, a knowledge of its position and condition for the preceding years will afford the means for judging of its probable character for the coming year and thus for predicting the nature of the coming season. If further investigation, founded on the comparison of the observations made in Natal with those made at the other observatories of the zone, lead to the confirmation of these results, then just as it will be possible to utilise the observations made here to give timely warning to the Australian colonies of the approach of atmospheric disturbances, so in turn will it be possible for us to receive early warning of approaching storms from either Australia or South America." He never reverts to this cyclic motion of the belt again, but this testimony to the correctness of the views that have been advanced, which suggested themselves to the writer quite independently, when analysing the movements of anticyclonic systems in the northern hemisphere, is of the greatest value and importance.

Cyclical Changes in Latitude are not confined to the Southern Anticyclonic Belt.

Such a change in the latitude of the southern anticyclonic belt, amounting probably to 9° or 10° of latitude, must effect some great alteration in that of the equatorial belt as well. In the reports recently published by the Director of the Egyptian Survey Department the movements of the equatorial rain-belt and the rainfall which results over the Upper Nile basin are gone into in great detail. He points out the connection which exists between the two, and gives the following table of the ratios of the Nile floods each year of the period from 1869 to 1905, to the mean flood during the 34 years 1869-1903.

TABLE XVI.—Ratios of Annual Nile Floods to Mean Flood.

1st Series.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	Remarks.
Floods	1·18	1·23	1·05	1·11	0·84	**1·26**	1·10	1·09	0·70	1·25	1·14	In excess
2nd Series.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.			Remarks.
Floods	0·98	0·93	0·84	1·04	0·83	0·99	0·91	1·19	0·72			Deficient
3rd Series.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.		Remarks.
Floods	1·00	1·12	1·01	1·20	0·99	**1·22**	1·15	1·06	0·89	1·07		In excess
4th Series.	1899.	1900.	1901.	1902.	1903.	1904.	1905.					Remarks.
Floods	0·63	0·89	0·87	0·63	0·89	0·75	0·65					Deficient

In this table the period 1869 to 1905 is seen to divide itself quite distinctly into four series. The first series, 1869-1879, consisted of floods which were in excess; the second series, 1880-1888, of those which were below the average of the thirty-four years; the third series, 1889-1898, of those which were again in excess; and the fourth series, 1899-1905, of those which were deficient. On referring to Table XIV. the first and third series are found to correspond with remarkable exactness to the years when the southern anticyclonic belt was north of its mean position, while the second and fourth series contain nothing but years when the belt was south of it. I may remind you that the years of the belt's

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mean cyclical position are the storm-cycle years discovered by Mr. Hutchins, and not years which I selected in any way.

As Sir John Eliot has already pointed out a connection between the Nile floods and the rainfall in India, and Sir Norman Lockyer has demonstrated that both of them have a relation to the periods of maxima and minima sunspots, there are good grounds for thinking that both the northern and southern anticyclonic belts move in harmony with one another, and in consequence of an external force.

If we wish to find an analogy for such a shifting in the latitude of our belts we have only to turn to the planet Jupiter. Since 1891 the Jupiter section of the British Astronomical Association has been investigating the movements of the belts of Jupiter, and has established conclusively that they shift their latitude. The annual reports find analogies to our terrestrial trade-winds, and frequently refer to rifts in the atmosphere resembling "cyclones" and to the "winds" and clouds of Jupiter. A large number of drawings of the planet's disc accompany the reports, and the shifting of the two important bands on each side of the equatorial band can be followed during the course of each apparition, in some years closing in upon the band, and at others opening out from it. In 1898 they are to be found closer to one another than in any other year from 1891 to 1904, and for some portion of the apparition they entirely obscure the equatorial band. After 1898 they move outwards to positions very similar to those they occupied in 1891. It is significant that in the year 1898 Jupiter was farthest from the sun, and this fact may have an important lesson contained in it for us. For the natural inference would be that the periods of maxima and minima sunspots would affect the latitude of our belts in a similar manner, and give rise to periodic variations in our weather such as have been discovered. It is reasonable that this should be the case, but Mr. Hutchins' examination of the sunspot cycle demonstrated that so far as South Africa was concerned the storm cycle of 9·5 years was more marked in the records than that of the sunspots. In some cases the latter was mitigated, and in others masked altogether by the former. It would almost appear that some other cause, not yet discovered, must be sought for to account for such changes in the belt's latitude as have been traced to be taking place in South Africa. In the previous inquiry into the movements of some of the permanent anticyclonic systems in the northern hemisphere, the conclusion was arrived at that between 1881 and 1891 a definite change took place in the latitude of their tracks. The present paper suggests, if it does nothing more, that in the year 1884 the southern anticyclonic belt reached its most southern position and began to come north again.

The whole matter certainly merits our attention, and appears to demand further investigation.

DISCUSSION.

Mr. F. C. Bayard inquired whether there was really an anticyclonic belt round the southern hemisphere, or whether it was a series of anticyclones without any belt, running east and west, which took a definite path one time, and another definite path another time.

The President, Dr. H. R. Mill, said that he wished to say how highly

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he, personally, had appreciated Colonel Rawson's paper, and the extremely clear way in which the various points were set forth. When they considered such phenomena as temperature or rainfall they were dealing with things influenced by a great variety of causes, but the distribution of atmospheric pressure was the determining cause of the whole range of weather, for it had the power of guiding the systems which produced precipitation and gave rise to changes of temperature. He believed that the variations of rainfall from year to year over the British Isles must be accounted for by some difference in the direction of the paths of the pressure systems which passed over the land. There had recently been a series of consecutive years, when one strip of country, in the east of England, was extremely dry, and there seemed to be no possible explanation of this except a divergence from the normal direction of the low-pressure systems as they crossed the country. Colonel Rawson had the advantage of dealing with a region, the observations from which had not yet been subjected to much study and theorising, but it was one in which the sequence of phenomena seemed to be both simpler and more regular than in Europe, and the outcome of his work might possibly be of the very greatest importance. They were now in a period when the science of meteorology in the southern hemisphere was being rapidly advanced. There had been a great development in Australia by the formation of a Federal Meteorological Service, New Zealand was going ahead, the different South African Colonies were, he hoped, soon to realise the importance of a general Meteorological System, and in the south of South America the greatest strides of all were being made. He considered that Colonel Rawson deserved cordial thanks for the great amount of labour he had expended on an extremely promising subject.

Colonel H. E. Rawson, in reply, said that he greatly appreciated the President's encouraging remarks. He hoped there were others present who would take up the subject with more advantages than he had. He had difficulty in obtaining access to the proper books of reference. If they were to take the years 1884 and 1893 as those in which the changes in the belt's oscillations had occurred, they would find that even in the northern hemisphere important results would be obtained. He had carried the inquiry on to India, and these were found to be peculiar years there also. With regard to Mr. Bayard's question, he did not share the opinion of Mr. Russell on this point. Our charts still showed the permanent systems, which were never absent from within the belt for a very long period. In some of the charts they could see clearly that the action-centre had a real progressive movement from Australia up to South Africa and back again. In the early months it was moving from east to west, and with the change of season, when the winter was over in South Africa, it began to move from west to east, and to go back to the vicinity of Australia. In the records of Mauritius its course could be traced both ways by the effects upon the barometer. Besides the so-called "permanent" anticyclonic system there were apparently secondary systems travelling within the belt quite independently of the main system. The main system was generally much more permanent over a district, sometimes prevailing for 14 days, while the little travelling systems might only stay at longest a couple of days. At the extreme ends of its course the main system would be found over much the same locality for weeks together, as was the case with the Siberian system in winter. But the whole matter requires much fuller consideration than it has yet received.

Captain M. W. C. Hepworth, in a communication to the Secretary, wrote :—

"Much to my disappointment I was unable to be present to hear Colonel Rawson read his paper, of which I received an advance proof, and upon which I beg to offer a few remarks. I think with Colonel Rawson that probably the anticyclones of the great oceans have, in addition to a seasonal oscillation, a

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movement that is cyclic ; but whether the earlier Pressure Charts he compares with those of a later date, in support of his theory, are based on a sufficient number of observations to be comparable, seems to me doubtful. It is true that the South-east Trades of the Atlantic, and, I may add, of the Pacific and Indian Oceans, are met with farther north of the equator in some years than they are in others ; but there is, I think, no evidence to show that the northern limit of these Trade winds is farther north, or farther south, during a number of years consecutively. There can be no doubt that variations in the meteorological conditions obtaining in South Africa are mainly the result of change in the track taken by cyclonic depressions in transit over that continent ; and that the track these wind systems follow depends upon the position of the high-pressure belt ; but the dominating factor, in my opinion, is the position of the South Atlantic anticyclone, the influence of the high pressure lying over the land being comparatively small. In regard to the monsoon influence referred to by Colonel Rawson as having been noticed at the Cape during the period 1896-1900, I have no recollection of a wind resembling a monsoon there during the six years 1878-1883, when I had good opportunities of observing and estimating the direction and force of the wind on the south and south-east coasts of South Africa. A North-west wind in Table Bay, and in the neighbourhood of the Cape, was usually associated with the passage eastward of a cyclonic or hemi-cyclonic wind system, and as a rule the wind increased to gale force in winter. Occasionally a steady North-west breeze was experienced, when the barometer stood at 30·0 in. or lower ; and was accompanied by rain, mist, or fog. Colonel Rawson says that 'As long ago as Maury's time, it was recognised that South-east winds blew out of the north side of the belt of calms,' etc. Recent investigation has shown that this time-honoured idea requires modification. The wind blows from southward and eastward across, and to the eastward and northward of the southern anticyclones of the oceans ; and its prevailing direction to the westward of the high-pressure area would be northerly (north-east to north-west) but for the interruption caused by the passage of depressions travelling eastward, and skirting the southern segment of the anticyclones.

"Referring to the connection Mr. Nevill pointed out, and Colonel Rawson has commented on, between the excessive rainfall in Natal of the seasons during the period 1892-1894, and the abnormal frequency of ice in the Southern oceans during the period 1901-1903, it seems probable that in consequence of a considerable increase in the activity of the polar currents in the latter period —currents which bring the ice from the Antarctic into lower latitudes—the temperature of the air flowing above them was lowered, and the energy of cyclonic depressions which bring to South Africa much of the rain increased, by coming in contact with this colder air ; the result being increased precipitation. In connection with certain anomalies in rainfall referred to in the paper, and with the differences alluded to between the rainfall of the eastern and that of the western sea-board, I would point out that the rainfall on the Atlantic side of South Africa is associated with equatorial winds circulating in front of depressions progressing eastward, pressure diminishing and temperature increasing. While the wind systems are passing over the arid land they part with much of their moisture, and take up little or none, so that when the system is approaching the eastern sea-board this equatorial wind is accompanied by a bright sky and genial weather. It then, however, becomes a sea-wind, bringing with it a fresh supply of moisture ; especially as it nears the coast, when an increasing amount of moisture is drawn from the humid atmosphere above the warm Agulhas current. The sky clouds over as the trough of the depression advances towards the sea and the air is near the point of saturation. After the trough of the depression has passed, and the wind has shifted to westward or

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south-westward—cold winds drawn largely from high latitudes—the rain descends, and continues to fall as the barometer rises and temperature falls. Similar conditions obtain in Australia; the west coast has its rainfall with equatorial winds, falling mercury, and rising temperature; the east coast with polar winds, rising mercury, and falling temperature. I consider Colonel Rawson's paper a very valuable contribution."

Ships Struck by Lightning.

Ships remote from the land are seldom damaged by lightning, despite the fact that some of the most awe-inspiring displays of atmospheric electricity are frequently witnessed by those on board of them. Standing rigging, and even parts of the running gear, are now made of steel wire; and this substitute for the old-fashioned hemp serves the purpose of a lightning-conductor when the ship is not fitted with such an aid to safety. The electric current is conveyed down the wire rigging, and reaches the sea through the vessel's metal hull. Damage only occurs if the current be interrupted on its way to earth. In a comparatively large proportion of instances the fore-royal truck is struck by lightning; that of the main less frequently; and the mizzen least of the three. Very serious casualties under this head occurred to warships and merchant vessels in the days of wooden hulls and hempen rigging. In July 1802, as thirteen sail of the East India Company were trying to round the Cape in the vicinity of Algoa Bay, homeward bound, two of them, the *Britannia* and the *Bombay Castle*, were struck by lightning. The foremast of each was soon enveloped in flames, and the two masts had to be cut away in order to save the ships and their combustible cargoes. A heavy gale was blowing, the night was dark, and the other ships of the fleet, which were hove-to at the time, were witnesses of this thrilling incident.

Many vessels are now fitted with lightning-conductors of approved types, lest the wire rigging should fail to carry off the electric current. In May 1896, shortly after a severe thunderstorm accompanied by lightning and rain in 3° S., 87° E., the P. & O. steamship *Victoria*, Captain W. D. G. Worcester, R.N.R., had a sudden increase of deviation amounting to 6° in both the standard and the wheel-house compasses, and later on it was discovered that the lightning-conductor on the fore had fused. The ship must have been struck by lightning during the storm. At 10·55 on the night of December 29, 1907, in 35° 50′ N., 21° 20′ E., the P. & O. steamship *Britannia*, under the command of Captain S. Bareham, outward bound to Sydney, N.S.W., came under the influence of a heavy thunderstorm, accompanied by vivid lightning, a deluge of rain, and very large hailstones. A strong West-north-west breeze was blowing, the external air temperature in the shade was 60°, and the corrected and reduced barometer reading was 29·67 in. This weather continued till 5.30 on the morning of the 30th, in 35° 0′ N., 23° 20′ E., and it was discovered that during the night the fore lightning-conductor had been fused in places, and that the strands of the last 10 feet of it had been opened out. Neither the *Victoria* nor the *Britannia* was injured, and this immunity from injury was doubtless due to the presence of lightning-conductors.—*Monthly Meteorological Charts of the North Atlantic and Mediterranean*, June 1908.

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RESEARCHES ON THE COMPOSITION OF AIR AT GREAT ALTITUDES, WITH SPECIAL REFERENCE TO ARGON AND ITS ALLIES.

By L. TEISSERENC DE BORT, F.R.Met.Soc.

The attention of men of science has long been directed to the question of the composition of air at various heights in the atmosphere, and from the time of the first employment of *ballons-sondes* by Hermite and Besançon, several attempts have been made to collect air from great heights by means of apparatus designed by M. Caillete, and one of these was successful. The quantity of air obtained was almost two litres, and it was analysed by M. Muntz, who found argon present in the normal proportion.

The existence of an isothermal layer in the atmosphere was discovered some years ago by our work with *ballons-sondes*, and has been demonstrated also in the region of the tropical Atlantic by the cruise of the *Otaria*, and under the Arctic circle by our Franco-Swedish expedition. The idea suggested itself to some people that this phenomenon of the stoppage of the diminution of temperature might be accounted for by some distinct difference in the composition of the air at high altitudes. Although I did not myself share this view, and had suggested a dynamical explanation of the isothermal layer, it seemed to me to be none the less interesting to investigate the composition of the upper air. My explanation was based upon the absence of vertical movements accompanied by adiabatic expansion in the isothermal layer, and thus tended to represent the portion of the atmosphere as having an individuality of its own, and not being mixed up by the vertical movements of cyclones and anticyclones, which tend to make the composition of air uniform by constant agitation in the lower and middle layer of the atmosphere. Thus if there is any difference in the composition of air with altitude, it should be accentuated between the isothermal layer and the portion of the atmosphere on which that layer rests.

As the *ballons-sondes* now in use are much smaller than Hermite and Besançon's aerophile, which was an expensive structure of gold-beater's skin, it was necessary to utilise very small vessels for securing the samples of air from a great height. I accordingly set to work to devise a vessel which should confine the air with absolute security, dispense with stop-cocks, [the automatic closing of which is difficult on account of the very low temperature of the high atmosphere,] and which should enclose the sample of air at a perfectly definite height. Electricity was the agent employed. The collecting vessel was a glass tube with a finely drawn-out end, which was sealed after a very perfect vacuum had been made inside. When the tip of the capillary tube was broken at the desired height the air was expected to enter readily, and fill the tube, so that it only remained to fuse the capillary tip in order to secure the sample. The tube is opened by the tip being broken off by the fall of a little hammer, released by an electric contact, and it is sealed by another contact allowing the current from a small accumulator to raise to

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red heat a platinum wire wound round the capillary tube, by which means heat is produced sufficient to melt the glass. Both contacts can be made either by the barometer at a pressure previously arranged, or by the clock-work of the meteorograph, and the whole operation is so conducted that no impurity can possibly affect the air in the tube, the apparatus being hung at such a distance below the balloon that there can be no trace of hydrogen in the air.

The apparatus, as first made on a very small scale, secured several little tubes of air in July 1907. I supplied several similar pieces of apparatus to the *Otaria* for use on the Atlantic; but the presence of salt in the sea air seems to have affected the contacts and they did not act properly

I pass over the various practical difficulties which presented themselves, and which have not yet been completely overcome. The very narrow limits of size and weight within which one had to work made the arrangements somewhat difficult, for it was necessary to use a very light accumulator and a very light glass receiver, which had also to be surrounded by a covering sufficiently strong and well hung to obviate the risk of breakage when it came to the ground.

The quantity of air collected was too small to permit of an ordinary chemical analysis, and I accordingly decided to confine myself to spectrum analysis, paying special attention to argon, neon, and helium. I have been confirmed in this decision by Sir William Ramsay, to whom I had the opportunity of submitting this matter in London in January 1908.

I have proceeded by two different methods: one, by absorbing all the elements of the air except helium and neon by means of carbon; the other by first separating the argon.

The result of the first experiment has proved the presence of argon in all the samples of air taken between 8000 and 14,000 metres (5 to 8 miles) as one would expect. Helium, distinguished by its yellow line in the spectrum, has been detected in most of the specimens, but the highest of all, that taken at 14,000 metres, showed no trace of it. Neon was clearly discernible in every case. The attempts to disclose krypton have not as yet given any result, but the experiments on this gas are not sufficiently numerous to permit of forming an opinion on the subject.

So far there has been no question of quantitative analysis, the volumes of helium and neon being so infinitesimal that it will be necessary to increase considerably the quantities of air collected, or to carry the technique of the operations still nearer to perfection before a quantitative result can be arrived at.—*Paris, June* 16, 1908.

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PRIZE COMPETITION FOR TEACHERS.

WITH the view of encouraging the teaching in schools of facts regarding weather and climate, the Council of the Royal Meteorological Society invited elementary teachers and others to send in for competition essays on weather or climate, for which prizes of £5, £3, and £2 respectively were to be awarded.

The requirements were that an original sketch of a Nature Study lesson on weather or climate (not exceeding 1500 words) should be sent in, together with a brief summary of five other lessons to cover the whole subject of weather and climate.

The number of essays sent in was 180.

The list of awards was given in the last number of the *Quarterly Journal*, pp. 153-154.

The essays by Mr. W. C. Upshall and Miss A. B. Phillips, who obtained the first and second prize respectively, are printed herewith. The essays were illustrated by diagrams and drawings of instruments, but these are not reproduced. The Society does not hold itself responsible for the statements made in the essays.

WEATHER OBSERVATION IN AN ELEMENTARY SCHOOL.

BY W. C. UPSHALL, BROUGHTON, STOCKBRIDGE, HAMPSHIRE.

For some years the writer has included weather observation as a part of the Elementary Science teaching in the Upper Standards—V., VI., and VII.—of a small village boys' school. In the schoolmaster's garden is a small grass plot on which stands a screen of the Stevenson pattern, and containing a maximum thermometer, a minimum thermometer, and dry and wet bulb thermometers. On the edge of the grass plot is placed a rain gauge. A home-made barometer is mounted on the school wall, making up all the necessary instruments for observing and recording weather observation.

At 9 a.m. each morning six boys are allowed to record the readings of the different instruments in a note-book kept for the purpose, and which is made out each month as follows:—

SPECIMEN FROM PAGE SHOWING ONE DAY'S READINGS.

January 7, 1908

Dry Bulb of Hygrometer	48°·5	
Wet Bulb of Hygrometer	48°	
Maximum Temperature	51°	
Minimum Temperature	43°	
Amount of Cloud—0 to 10	10 Ni	
Rainfall in Inches	·88	
Barometer 29·35 corrected	29·25	51° F.
Remarks ⌒ ≡ stormy. ◍ at night . .		W.

Full instructions for observing are given in *Hints to Meteorological Observers*, by W. Marriott, F.R.Met.Soc., 1s. 6d.

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At the end of each week the boys graph the readings on squared paper, and at the end of month the totals and averages are found.

General Lesson on Forecasting Weather.

Note.—It is not intended that the whole of the following should be included in one lesson, there being enough subject-matter to occupy several lessons.

I. *Weather Forecast for the Day.*

(*a*) Draw attention to the general weather forecast for the day in the daily paper. Reference will very likely be made to a disturbance somewhere in the Atlantic. Produce a chart showing storm tracks, and it will be seen that the British Isles lie right on the great highway of storms which can be traced across the Atlantic, and following, or in close proximity to, the course of the Gulf Stream. Note that the storms do not keep exactly the same track, or otherwise the same countries would always come under the influence of the relatively same part of succeeding storms.

(*b*) A simple illustration of a storm may be found in the whirlwinds of dust seen in the country at different periods of the year. Such a phenomenon has often been observed by the boys at the school from which this is sent. These volumes of dust whirl around and sweep forward up the hill. It will now be an easy matter to show how atmospheric disturbances may be set up by the unequal heating of different layers or portions of the earth's atmosphere.

The land and sea breezes occurring in the summer-time should also be observed and made a note of in connection with the same.

II. *A Cyclone.*

(*a*) In recording weather observations the boys will have noticed that the barometer reads highest in fine weather and falls as the weather becomes stormy. It should now be explained that every morning at eight o'clock messages are sent to the Meteorological Office in London from scores of places throughout the kingdom, telling the height of the barometer and the direction and strength of the wind, along with other particulars. The height of the barometer is marked down for each place on a blank map, and then lines are drawn through all places where the heights of the barometer are equal. These lines are called "isobars," and when so drawn always show either a number of concentric circles or a spiral.

Two charts illustrating these should here be shown to the pupils and explained.

When the barometer reads lowest on the inside we have what is known as a cyclone system, and when highest in the centre an anti-cyclone.

The wind whirls towards the centre in a cyclone, rushing in from all sides to fill up the place of the ascending warm air.

(*b*) Some day should be chosen when the weather forecast predicts an atmospheric disturbance. The pupils should be allowed to go outside

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at various times—of course opportunely—chosen by the teachers, and note the atmospheric conditions, *e.g.* kinds of clouds, direction of wind, strength of wind, rain, barometric height. All of these should then be arranged by the teacher in proper sequence, so that the correct conclusions may be drawn.

The following conditions and sequence of events may commonly occur:—

A fine bright morning with a clear sky. To the west and south may perhaps be seen a faint haze. Perhaps in comparing the direction of the wind with the previous day it will have been found to have shifted from North or North-west to West and South. When the wind shifts in this direction it is said to "back." The pupils should make a sketch thus, showing circular movement of direction of wind. Streaks of clouds—Cirrus or Mare's Tail—may be seen, and these are followed by denser streaks, which gradually merge into a mackerel sky. As the wind changed from uncertain gusts to a stormy gale, the clouds varied from Cirro-Cumulus to Cumulus and Nimbus, while the rain increased from a drizzle to a steady downpour. By this time perhaps the wind would be blowing a hurricane, while the clouds drove across the sky furiously.

During this the height of the barometer should be noted every half-hour, and the alteration graphed on squared paper.

At some period there would be a lull in the storm and the graph of the barometer at this time stands lowest. This is called the "eye of the storm." Later on in the day the wind again increases, clouds cover the sky, and the rain falls heavily. The wind will now be found blowing from the East, North, or even perhaps North-west. On noticing the barometer we shall find a steady rise, which should be graphed as before.

(*c*) The teacher should now draw a diagram of what has been observed, the class copying it in their note-books.

Very often a storm such as has been described is followed by "secondary depressions," or smaller storms shorter in duration, but of no less violence.

In connection with the foregoing the amount of rainfall occurring during the gale should be observed and recorded.[1]

It should be noted that the front part of a cyclone is always very damp and warm; the rear cool and dry. To observe this readings of the hygrometer and thermometer should have been taken and graphed on squared paper. The lines showing readings of dry and wet bulb would be closer together at front of storm than at the rear.

III. *An Anticyclone.*

(*a*) Just as in the case of the cyclone, an opportune time should be selected for the lesson, and this can be chosen from the forecast given in the daily paper. Let this be read out to the class by one of its number. It will be necessary to extend the observations over several days, noting the readings of barometer, hygrometer, direction of wind, clouds, and temperature. All these to be carefully graphed.

[1] On more than one occasion the rain has been observed to be coloured, and then the boys have examined drops under the microscope. A small quantity can be evaporated and the sediment examined in the same way.

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Having thus made the necessary preliminary observations the lesson on the anticyclone can be proceeded with.

(*b*) 1. A chart illustrating the barometric readings over that portion affected by an anticyclone should here be shown. Notice that the "isobars" are circular or nearly so, and that the highest reading of the barometer is towards the centre.

2. The winds circle in the opposite direction to that of a cyclone, being accompanied with blue sky, and pleasant freshness of the atmosphere. In winter we have brisk frosty weather, and in summer misty mornings followed by fine bright days.

3. Point out that in the cyclone the air pours in towards the centre and goes upwards, afterwards to spread out and descend down the centres of the anticyclones.

THE HYGROMETER.

Measuring the amount of water vapour in the atmosphere. Two Lessons.

I. *Absorption of Water by Solids and Liquids.*

Experiment 1.—Take lumps of chalk, sugar, etc., placing in a little water coloured with red ink. Weigh these before and after to show the amount of water absorbed in each case.

Experiment 2.—Take two beakers of the same size and height. Fill one with water to a certain measured height from the bottom. Weigh beaker first, and then beaker and water.

Do the same with the other beaker, using sulphuric acid instead of water.

Put both on one side for a few days and then examine. Weigh both again, and it will be found that the sulphuric acid has increased both in volume and weight. The liquid sulphuric acid presumably has absorbed some substance.

II. *Proportion of Moisture in the Air.*

An ordinary large jam-bottle—about 200 c.cm. capacity—is fitted with a cork in which are inserted two pieces of bent glass tubing. Two pieces of india-rubber tubing are fixed in the end of the bent glass tubing, one rubber tube being allowed to extend to an empty beaker placed below the level of the bottom of the bottle, so that when the experiment starts the water can be siphoned from the latter to the former.

In the glass tube, which is 10 ins. long and ½ in. in diameter, is placed some calcium chloride—a hygroscopic substance.

The tube containing the calcium chloride is carefully weighed, replaced, and the water allowed to run from the aspirator, afterwards measuring the volume of water drawn off. This will represent the volume of air which has passed over the calcium chloride in the tube.

Now weigh the tube, finding its increase in mass.

All this experiment can be performed by the boys themselves.

Record the results thus—

Weights of tube and $CaCl_2$	before exp.	32·50 grms.
„ „ „	after „	33·65 „
	Increase . .	1·15 „

Vol. of H_2O in bottle and therefore vol. of air, 200 c.cm.

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III. *Experiment with a Dry and Wet Bulb.*

(*a*) Two unmounted thermometers are mounted on a retort stand. The left-hand bulb is covered with a piece of muslin which dips into a vessel containing water.

As soon as the muslin is thoroughly damp examine readings of the bulbs. Let the observation be repeated at different intervals during the day and on successive days, graphing the results on squared paper.

(*b*) Explain that the lower reading of the wet bulb is due to evaporation. In changing from the liquid form to a vapour the molecular state of the water is changed. Heat is the force which lessens the force of cohesion between the molecules of water, allowing it to become vapour, and this heat is taken from the mercury in the wet bulb.

The Barometer.

Outline of Lesson. Two Lessons.

I. *Pressure of the Atmosphere.*

Experiment 1.—The sucker cannot be pulled off easily, because the air is pressing on the top of it, but not on the lower side.

Experiment 2.—The paper does not fall off the tumbler although the glass is full of water. This is owing to pressure of air on the paper.

Experiment 3.—The funnel has a thin sheet of india-rubber tied over the top. When the air is sucked out of the funnel the india-rubber presses inward in the form of a curve.

Experiment 4.—Get an air-pump and hand-glass. Allow several pupils in turn to put one hand on the glass while the air is being exhausted. Hand cannot be removed. This shows clearly that air has weight.

II. *Torricelli's Experiment.*

(*a*) Take a barometer tube about 34 inches long and fill it with mercury. Place the thumb over the open end and invert the tube, removing it to a cup of mercury.

A column of mercury now remains in the tube about 30 inches in height. Note that 30 ins. = 762 millimetres.

(*b*) Experiment to show that mercury stands at same level when the tube is inclined :—

When the tube is in vertical position the mercury stands at the height of 30 ins.

On inclining the tube the mercury still stands at the same level.

(*c*) Experiment to show that pressure of a column of mercury is 15 lbs. to sq. inch :—

Suppose the tube to have an area of 1 sq. inch in transverse section. Then the mercury balanced by the atmosphere consists of 30 cubic inches.

Now mass of 1 cu. inch of mercury = $\frac{1}{2}$ lb. nearly.

$\therefore$ „ 30 „ „ = 15 lbs.

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III. *Construction of a Simple Barometer.*

Procure a barometer tube about 34 inches long; a piece of rubber tubing about 9 inches long and which will fit the barometer tube; a piece of glass tubing which will also fit into the rubber tubing.

Next get a smoothly planed piece of pine wood about 4 ft. by 6½ inches, and on this rule two red ink lines 32 inches apart. Carefully rule out a scale of inches and tenths on a piece of drawing-paper, gumming it on the board. A scale of millimetres may be placed on the other side, leaving just room enough for the barometer tube. Note 27·4 ins. = 696 mm.

In order to fill the tube fix the rubber tubing on the open end of the barometer tube and place a small funnel in the other end of the rubber tubing. Gently pour in the mercury until it fills the barometer tube and nearly three-fourths of the rubber. Now take out the funnel and put the short piece of glass tubing in its place.

It is now ready to place in position on the board, to which it is secured by clips. This must be done with great care, or otherwise air will get into the vacuum at top.

The clip holding the glass tube at the open end must be made to unscrew so as to adjust the level of the mercury at *g* each time a reading is taken.[1]

Crook's Vernier Ruler, 2s. 6d.—Harling, London—will enable the observer to read hundredths of an inch.

A piece of cotton wool in tube above the open end keeps out the dust.

IV. *How to measure Heights above Sea-Level.*

(*a*) Weight of atmosphere varies with height above sea-level.

Experiment with Spouting-jar.—Show that the pressure of a column of water varies with the height of the column.

The same follows with a column of air.

For every 1000 feet we ascend the mercury falls 1 inch; approximately, on the other hand, in descending a coal-mine the mercury rises the lower we go—1000 ft. in descending, mercury rises 1 inch.

(*b*) Weight of atmosphere varies according to quantity of vapour contained.

Experiment.—Boil a flask of water and note that the vapour ascends. Why does it ascend?—lighter than air.

Vapour is lighter than air.

Note that evaporation is always more or less going on from the surfaces of pools, streams, and seas.

Moist damp air is light; dry air is heavy.

The Thermometer.

It is here taken for granted that lessons have been given to the pupils on the thermometer while in a lower Standard.

[1] Such a one has been made and used by the writer for some years.

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I. *Graduating the Thermometer.*

(*a*) *The Freezing Point.*—Place some pieces of ice in a beaker and notice the reading of the thermometer when placed in it. If the beaker be warmed so as to melt the ice the thermometer reads the same so long as any ice remains unmelted.

Use both a Fahrenheit and a Centigrade thermometer in this experiment.

"Freezing point of water is the melting point of ice."

Explain that the heat used up to melt the ice, or, in scientific words, "to alter the molecular constitution of the solid ice," is not recorded and is known as "latent."

Freezing point marked 32° on Fahrenheit thermometer.
" " " 0° " Centigrade thermometer.

Take a mixture of salt and ice and notice that the melting ice then shows a lower temperature.

Tell the story that when Fahrenheit constructed his thermometer he supposed that 0° F. was the lowest degree of cold which was obtainable.

(*b*) *The Boiling Point.*—Take a test tube as in the accompanying diagram. When the water boils note the temperature, making use of both a Fahrenheit and also a Centigrade thermometer.

Note that the mercury is stationary at boiling point.

Explain that the heat used up to turn the water into steam, or, in scientific words, "to alter the molecular constitution of the liquid water," is not recorded and is known as "latent."

Boiling point marked 212°, *i.e.* 32° + 180°, on Fahrenheit.
" " " 100° on Centigrade.

II. *To compare the Readings on Fahrenheit and Centigrade Thermometers.*

(*a*) By diagram show that

100 divisions Centigrade = 180 divisions Fahrenheit.
5 " " = 9 " "

(*b*) Maximum and minimum Thermometers.—These to be shown and the uses explained—and how to read them.

(*c*) Exercise in changing degrees Fahrenheit into Centigrade. Let each boy draw a graph. Practise in reading from graph, *e.g.*

0° C. = 32° F. 30° C. = 86° F. 60° C. = 140° F.

Show that in turning F. degrees into C. we must first subtract 32°.

Also when changing C. into F. add 32°.

Give exercises to be worked and each pupil check on graph.

The Rain Gauge.

Principle of the Rain Gauge.

(*a*) Take an ordinary jar or tin fitted with a funnel so as to nearly resemble a rain gauge. Now pour water into the jar through the funnel to height of ½ inch. Next procure a long narrow glass jar, pouring the water from the ordinary jar into this one.

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Take a strip of paper the height of the water in the long glass and divide it into 50 equal parts. Paste it on the narrow glass jar and it becomes the measuring-glass.

We are now able to measure so small a quantity as $\frac{1}{100}$ of an inch or ·01 inch.

(*b*) By measurement we find that

1 gallon of water = 277·274 cubic inches

i.e. $l \times b \times h$ = 277·274 „ „

Suppose the area of a funnel to be 2 square feet.

$\therefore \quad 2 \times h = 277{\cdot}274$ cubic inches

$(2 \times 144)\ h = 277$

$\therefore \quad h = 1$ nearly.

Thus 1 inch of rain is equivalent to 1 gallon of water spread over 2 square feet.

(*c*) Show how to graphically record the rainfall collected day by day.

NATURE STUDY.

By Miss A. B. PHILLIPS, 34 Blythe Hill, Catford.

Scheme of Six Nature Study Lessons on Weather and Climate, suitable for children of an Average Age of 10 years in an L.C.C. Elementary School.

1. An Autumn Morning: formation of Dew, Mist, and Fog.
   A Winter Morning: appearance and formation of Frost.
2. Clouds: their formation, appearance, and movements.
   Rain, Thunder, and Lightning.
   A Rainbow.
   Hail and Snow.
3. The Rain Gauge. The Barometer. The Thermometer.
4. The Weathercock: the Wind and its effect upon the Weather.
5. English Climate contrasted with that of Tropical and Frigid lands.
6. Natural conditions affecting Climate.

Note.—This subject could not be covered satisfactorily *with children* in six lessons; each of the above with children's observations and questions would make two or three lessons.

Lesson I.

An Autumn Morning. Time, 1 hour. *Class* 4. Average age 10 years.

Some of you came across the park this morning coming to school, and the shortest cut is across the grass plot. Did you notice your boots after this? Yes, they were quite wet and all the bright polish gone—*the grass was wet.* Did you notice dampness anywhere else? Yes, some *plants near the ground* had drops of water, like bright beads, glistening upon them; yet you know it had not rained during the night.

What was this water? It was *Dew. Whence come*, and *how formed?* This question you cannot answer, you were not up or out early enough to know. Well, have you seen this same condition at any other time of the day? *In the evening.* Mother has often said, "Come off the grass,

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dear, it is getting damp," and yet you know then certainly that no rain has fallen. How, then, has it come?

Here is a glass of cold water which Mary has just brought in; she will tell you that she found it standing in a basin surrounded by ice, where it has been for the last half-hour. Now watch and tell me what is happening. Yes, the glass is getting misty, and now you can see drops of water on it. Do you think they have come from the water in the glass? No, they are on the outside, and glass would not allow it to get through, for it is, for all practical purposes, non-porous; beside which it stood all the previous half-hour, and there was no sign of damp until it had been some seconds in the warm room.

Now we have learnt before that there is *always water vapour in the air*, sometimes more, sometimes less, but always some, but *I must tell you* what you do not yet know, that *warm air will hold more water vapour than cold air.*

Now the air in this room is warm and charged with water vapour. If it is cooled at all (which it *is* by the presence of the ice-cold water and glass), some of this vapour is given up in the form of water (*condensed vapour*) as you see it on the glass.

This is what has happened in the field. The ground, which has been warm all day, and has been warming the air immediately above it, gets cool very quickly, much more so than the air. Every blade of grass and leaf, etc., grows cool, and the warm air touching it is chilled by the contact and gives up part of its water vapour in the form of these drops.

Formation of Mist and Fog.

When we were practising for the races some month or two back, do you remember that you had to leave off in the middle of the races, because the atmosphere became quite thick so that we could not see, and one of you said it was *a white fog.* Well let us see if that had anything to do with the water vapour of the air. Can you guess why it is so often misty and foggy here at C——, especially in and near the park? Well it is partly because there is so much water. The streams that add so much to the beauty of the place are partly the cause of the discomfort.

All day the sun is warming the water and the land (you know how hot the ground is if you sit down on the grass at midday, and the water is similarly warm).

The air lying immediately over the earth and water is being warmed, *not by the heat of the sun's rays streaming through it*, but by radiation from the land and water.

As evening comes on and the sun goes down, neither the water nor the land receive any more heat. They now begin gradually to cool, and as the land gives up its heat much more rapidly than the water, the air in contact with the land gets much cooler than that over the water, and when these two bodies of air meet, the cooler chills the warmer, and the same phenomenon occurs (the same thing happens) as in the case of the dew, only *the condensation is more gradual and not so thorough*; and the water vapour becomes visible, and remains as a mist or fog closely over the earth.

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Now you have learnt how mist and fog are formed (by the meeting of air of one temperature with *some* body of a lower temperature).

People from the country are often puzzled by the blackness of London fogs—this is due to the smoke and dust of the city. Town fogs are *usually* thicker and darker than country or sea fogs.

Perhaps, now, you can see why, when *the sun comes out*, if it shines for any length of time, *the mist or fog disappears*—it is because the air is again receiving warmth from the earth, and that is *changing* the same condensed vapour *back into its true vapour* condition, in which *it is invisible.*

A Frosty Morning.

I now want one of you to tell me what the garden looked like this morning, when you got up and raised the blind.

The grass, thickly covered with white, looking in the distance like a thin coating of snow—the plants edged with white and glistening—bare trees encrusted with the same—the air bright and keen.

What is this which we call *frost* [Hoar-frost]? *Where does it come from?*

It is formed in very much the same way as dew, only before the water has time to form on the leaf, as in dew, it has frozen and *ice is deposited instead of water.*

What becomes of it? It disappears when the sun comes to it; yes, it is dissipated by the warmth and evaporated.

Summary of chief facts taught.

Dew is formed after sunset.
Dew is formed by the condensation of water vapour from the air.
It is found only near the ground.
Water vapour is always present in the air.
Warm air will hold more water vapour than colder air.
Hoar-frost is frozen vapour.

Summary of Lessons.

Lesson II.

Clouds:—

(*a*) Masses of vapour floating in the sky.

(*b*) Formed by constant evaporation—vapour lighter than air—rises—higher it goes colder it becomes—cold air condenses—becomes visible and is driven in various directions by the wind.

(*c*) Sudden fall in temperature causes particles to run together and fall *as raindrops.*

If they pass through colder layers of air in descent, the drops are frozen and drop *as hail.*

If frozen before descent commences they fall *as snow.*

Thunder and Lightning. — When two cloud-masses meet *Electricity* is *generated* and discharged, and *the report* of the discharge is *heard as thunder.*

Some materials are better conductors than others—means used to prevent danger—conditions to be avoided during a thunder-storm.

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Rainbow.—Prismatic colours—due to refraction—raindrops as prisms—position—back to the sun.

Reason of rounded shape is the roundness of the raindrops—try looking through angular prism.

Lesson III.

Rain-gauge.—Show one, or make a model. Can be seen at Greenwich.

Note.—Funnel, Can, Measure.

Barometer.—Same method followed in this case. Have a barometer. Pressure of air. Scale for measuring variations.

Thermometer.—As above. Warmth of air, marked by scale. Children should keep daily records of the last two if possible. If they attend the science school, they would be more interested after making the instrument in a simple form.

Lesson IV.

The Weather-cock:—

(*a*) Children have been noticing it daily and *keeping record.* State more clearly for the class what they have observed. Smoke will often tell the direction of the wind.

(*b*) *Direction* in which the *school lies.* Children notice and tell later the direction of their own house.

(*c*) *Method of naming winds,* by the direction *from* which it blows.

(*d*) This will often tell us the *character* of the *wind*; according to the land or sea, heat or cold of its passage.

The weather-chart, kept by class, can be used here.

Lesson V.

English Climate contrasted:—

(*a*) *Zones* of climate. Torrid. Temperate. Frigid. Stories and known *facts concerning these, e.g.*—

1. Desert travellers. Sailors going through Red Sea. Missionaries of India, etc.
2. Life here at home.
3. Stories of Franklin, Davis, and other Arctic explorers. Life of Laplanders and Esquimaux.

(*b*) *Direction of the sun's rays* (briefly and simply).

Lesson VI.

Natural Conditions affecting Climate:—

The Latitude will not always satisfactorily account for climate. Other conditions modify—

(*a*) Height above sea-level.

(*b*) Nearness to ocean or sea.

(*c*) Sheltered or exposed condition of country; direction of mountain ranges intercepting winds.

(*d*) Character of the prevailing winds.

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(*e*) Where near sea, influence of warm or cold currents.

In connection with known Geography, this lesson will be more interesting.

Brilliant Sky Glows, June 30 and July 1, 1908.

Brilliant sky glows were observed in many different parts of the United Kingdom on the night of June 30 and on several succeeding nights, the phenomenon being apparently at its maximum intensity on the night of July 1. The whole of the northern part of the sky, from the horizon to an altitude of about 45°, and extending to the west, was suffused with a reddish hue, the colour varying from a pink to an Indian red, whilst to the eastward of north the colour was distinctly a pale green. No flickering or scintillation was observed on the reddened sky, nor was there any tendency to the formation of the streamers or luminous arch characteristic of aurora. Cirro-stratus clouds near the horizon were tinged with the same colour as the surrounding sky. A special feature in connection with the phenomenon was the prolongation of twilight, extending almost to the following daybreak, and from the experience cited by many observers in various parts of Great Britain the light at midnight was sufficient to allow of fairly small print being read without any aid from artificial light.—*Nature*, July 9, 1908.

Mr. J. W. PHILLIPS of Haverfordwest, in a letter dated July 2, said :—

"On the last two evenings (June 30 to July 1) I have observed here the most unusual prolongation of twilight, in fact it did not become dark or anything approaching it on either of the dates named.

"On the 30th a police constable on night duty told me he was able at 12.30 to distinguish people more than 100 yards away, and at 1 A.M. it was as light as dawn, the sky then having peculiar greenish and yellowish tinges. Last night at 10.15 P.M. it was quite easy to read a newspaper in the open air, and at 12 and even 1 A.M. I could read my watch easily. The light extended from north-north-west by north to north-north-east, and had not the appearance of aurora, the amount of cloud being about 5 (ci.) and almost calm. Many persons mistook the time and thought their watches had stopped.

"Upon inquiry at the Atlantic Relay Office, I find that no earth-currents have been recorded of late, and a message was received from Valencia that they had observed the lengthened daylight, but had noticed no earth-currents."

Prof. BOHUSLAV BRAUNER of the Bohemian University, Prague, in a letter to *Nature* of July 9, said :—"The peculiar light phenomenon at midnight on June 30 which was seen, according to the papers, on the northern part of the sky at Copenhagen, Königsberg, Berlin, Vienna, Biala, and other places, was also observed by me at Prague. At 1.30 A.M. on July 1, I saw, in the direction north-east and north-north-east, a peculiar strong orange-yellow light over the horizon, the colour of which was more orange in its lower parts and more yellow in its higher parts. Its upper limit was lying twenty to thirty degrees above the horizon. The whole sky was cloudless. Other people saw it here at 11 P.M. on June 30. It is reported that magnetic disturbances were experienced on the telegraph lines, but I saw no trace of the characteristic of auroral bands or columns. I may be allowed to add that, according to Arrhenius, this time of the year corresponds to the minimum auroral display (activity). Interesting is the fact that a high barometric maximum was lying in the north, and that we had winds from that direction for a whole week."

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PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 11, 1908.

Ordinary Meeting.

Dr. HUGH ROBERT MILL, President, in the Chair.

JOHN EWART TROUNCE BARBARY, 49 Dolcoath Road, Camborne;
EDMOND HUBERT BRANDT, 15 Lennox Gardens, S.W.;
ELIJAH HOWARTH, F.R.A.S., Weston Park Museum, Sheffield;
ARTHUR EDWARD JONES, 2 St. Mark's Square, Regent's Park, N.W.;
WILLIAM RICHARDSON NASH, Carke-in-Cartmel, Lancashire;
ARTHUR A. RAMBAUT, D.Sc., F.R.S., Radcliffe Observatory, Oxford; and
GEORGE PENN SIMKINS, P.H.D., Dacca, Bengal,
were balloted for, and elected Fellows of the Society.

THE PRESIDENT, Dr. H. R. MILL, said that he had much pleasure in making a statement with respect to the competition initiated by the Society with the object of ascertaining the extent to which meteorology was understood and taught in Elementary schools in this country. The Society had offered three prizes for the three best essays by teachers and others on "Climate and Weather," the essays to be in the form of a lesson, and accompanied by a syllabus for a complete course of lessons. The essays received had been more numerous than was anticipated, no less than 180 having been sent in. These had been considered by the Local Scientific Societies' Committee, and Mr. Bayard had kindly undertaken the task of going through them and sorting them. Mr. Marriott had then read them, and carried the classification farther, and, after a final scrutiny by Mr. Bayard, the result was as follows:—The first prize of £5 is awarded to Mr. W. C. Upshall, of Broughton, Stockbridge; the second prize of £3 to Miss A. B. Phillips, 34 Blythe Hill, Catford; and the third prize of £1 to Mr. Albert Stevenson, St. Paul's School, Sunderland. In addition to these prizes, it has been decided to award two extra prizes of £1 each to Mr. John Young, of Barrock by Wick, and Mr. Henry Collar, of Lavender Hill School, Clapham Junction, whose essays were very close to the first three. Two prizes have also been awarded to pupil teachers: £1 to Mr. Arnold B. Tinn, 28 Macaulay Road, Birtley, Huddersfield, and 10s. to Miss Daisy E. James, Church House, Wokingham. A considerable number of the essays had been sent in by children, and prizes have been awarded to Stewart Dobson, 70 St. John's Park, Blackheath, and Lily Francis, Black Notley School, Braintree. The result of the competition showed that the study of the weather had been handled intelligently in many schools, and it was hoped, that having thus received these various suggestions from teachers and taught, the Society would be able to found upon them some definite suggestions for the improvement of teaching this subject in Elementary schools.

THE PRESIDENT said, that the formal business of the evening being completed, he had the extremely pleasant duty of introducing to them the lecturer, though there was no one among the eminent meteorologists of the world who required less to be introduced to the Society than Dr. Hellmann. Dr. Hellmann was not only an Honorary Member, but he had been present on a comparatively recent occasion, the Jubilee celebration of the Society, when he had officially represented the German meteorologists in conveying their congratulations to the Society. All those who were present at that time would look forward with pleasure to the subject of Dr. Hellmann's lecture. The present meeting

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was graced by the presence of representatives of the German Embassy and of the German Consulate-General, whom he welcomed with pleasure. He had also received a considerable number of apologies from those who were unavoidably prevented from being present. Among these he regretted in particular the absence of the President of the Royal Geographical Society, Sir George T. Goldie, who wrote, he was sorry not to be able to honour the President of the Berlin Geographical Society by coming to his lecture, but although he did not wish to charge the Meteorological Society with any undue responsibility, it was the state of the weather that rendered it impossible for him to come out. Dr. Hellmann had made a very special study of the early history of meteorology, on which he was the leading authority, and it was a great honour to the Society that he should have been willing to come on this occasion, despite great personal inconvenience, and he had come across the North Sea through the heart of one of their best developed cyclones. He, the President, was sure that all present would accord to Dr. Hellmann the heartiest of welcomes.

Dr. G. HELLMANN then delivered a lecture on "THE DAWN OF METEOROLOGY."

[This Lecture will be printed in the next number of the *Quarterly Journal*.]

Dr. W. N. SHAW said that it was his privilege to propose a vote of thanks to Dr. Hellmann for his extremely able and interesting lecture. He felt more or less at home in proposing this vote of thanks, because Dr. Hellmann, as a Director of the Prussian Meteorological Institute, was a colleague of his as Director of a Meteorological Office. He was not betraying any great secret in saying, that the Director of an Institute was a peculiar person in this respect: he went to his work late, and made up for it by leaving early. He also had no special duties, but got the credit for all the work done by his assistants. Dr. Hellmann, as a Director, was in a favourable position for absenting himself from his office, but he, Dr. Shaw, was certain that Dr. Hellmann shared with him the feeling, that somehow or other the office got on better if the Director were regular in his attendance. It might be just a matter of taking an interest in the work of this or that department, but the work would be much improved. It was therefore the greater sacrifice for Dr. Hellmann to absent himself, and they would all unite in a vote of thanks to Dr. Hellmann for his kindness in coming that night. The lecture was a profoundly interesting one, as it dealt with a part of the subject seldom otherwise touched upon, also the manner in which it was presented would ensure that every one would carry away some idea of the story of the dawn of meteorology. Moreover, this story had been told in a language which was not the language of the lecturer. He, Dr. Shaw, had tried to make himself understood in other languages, and could heartily congratulate Dr. Hellmann on his success in overcoming the difficulties of a foreign tongue. Dr. Hellmann had discussed the Dawn of Meteorology. There was a very great effort being made in this country towards the progress of meteorology. He hoped that, although the dawn of meteorology extended back to a very long time, even before Babylonia, Dr. Hellmann might be spared to come back and give them another lecture on the "Noon of Meteorology." He had great pleasure in proposing a vote of thanks to Dr. Hellmann.

Mr. RICHARD BENTLEY said that—though difficult to glean in a field already traversed, and to-night so happily by Dr. Shaw—he rose very cordially to support the resolution conveying the thanks of the Society to their distinguished guest. When the first tidings of Dr. Hellmann's intention to visit this country had become known among the Fellows it had afforded them the liveliest satisfaction to welcome him again in their midst. To-night, however, to those fortunate in being present that pleasure had been increased tenfold after the interesting discourse they had just listened to, and it was also felt to be a great compliment to the Society that a meteorologist of the high position and

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international eminence of Dr. Hellmann should come especially for this particular occasion all the way from Berlin (and that too at an inclement season of the year) to give the fruits of his labours to others in this country interested in the science. In recent years, owing to the great improvement in the manufacture of automatic and other scientific instruments, and the synchronous records of observations over wide areas rendered possible by the development of telegraphy, the progress of meteorology on modern lines had been very considerable. From this very cause, however, there was some danger of the historic side of this science being overlooked, and so they were still more indebted to Dr. Hellmann for helping to fill this void by the exceedingly valuable and complete survey which he had given to-night of the genesis of meteorology; indeed, within the brief compass of a single hour he had been successful in summarising the labours and investigations of more than twenty years. His audience had not only profited by the knowledge of so expert an authority on all pertaining to weather, but also by the researches of a distinguished scholar, and they were glad to have such a mass of valuable information enrolled in the pages of the Society's Journal. He (Mr. Bentley) had therefore great pleasure, on behalf of all present, in seconding the resolution.

THE PRESIDENT said that it was almost superfluous for him to put to the meeting the vote of thanks which had been so well proposed and seconded, and so enthusiastically received, but as formality sometimes made it necessary to do superfluous things, he had, in their name, to express to Dr. Hellmann their very deep appreciation not only of the excellent lecture, but also of his kindness in coming so far to give them the benefit of his great learning on the evening which was always expected to be the most attractive meeting of the year. These lectures were important because they seemed to show, not only to the Fellows, but the outside world, that the Royal Meteorological Society was carrying on work which, important as it was in the present, had its root in the distant past; that it dealt with principles which, besides embodying the results of modern science, had in many cases been foreshadowed by the ancients. He did not think that they had ever before succeeded so well in placing before the public this idea of the antiquity and the dignity of meteorology as to-night when listening to this address.

Dr. C. HELLMANN, replying, said that he thanked them all, and especially his colleagues, Dr. Shaw and Mr. Bentley, for their very kind welcome. He hoped that some day an English meteorologist would come and give a lecture to Berlin on the state of meteorology in England.

THE PRESIDENT remarked that a copy of the facsimile of Merle's Journal was on the table, and he invited any one desirous of inspecting this interesting volume to do so.

April 15, 1908.

Ordinary Meeting.

Dr. HUGH ROBERT MILL, President, in the Chair.

CHARLES BROWETT, Ryton-on-Dunsmore, Coventry; and
ALEXANDER MACMORAN, K.C., 3 Temple Gardens, Temple, E.C.;
were balloted for, and elected Fellows of the Society.

Geheimrath Prof. Dr. RICHARD ASSMANN, Director of the Königliche Preussisches Aeronautisches Observatorium, Lindenberg, Kreis-Beeskon;

KIGOO NAKAMURA, Director of the Imperial Meteorological Observatory, Tokio, Japan; and

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Prof. ABBOTT LAWRENCE ROTCH, M.A., B.Sc., Director of the Blue Hill Meteorological Observatory, Hyde Park, Mass., U.S.A.,
were balloted for, and elected Honorary Members of the Society.

THE PRESIDENT, Dr. H. R. MILL, said that it was with great regret he was again obliged to preface his remarks with a reference to the death of one of the leading British meteorologists—on this occasion that of Sir John Eliot. Although Sir John Eliot had completed his great Climatological Atlas of India, embodying the fruits of his labours as head of the Meteorological Service of India, he died before the volume of text accompanying it was ready for publication. He had been a member of the Council of the Society, and, though his residence abroad had prevented frequent visits to the Society, his work had made him familiar to all the Fellows.

The President mentioned that, in connection with the Bill for improving Agricultural Education now before Parliament, he had taken the opportunity of following the example of his predecessor, Mr. R. Bentley, and had written to the Right Hon. Jesse Collings, M.P., who had charge of the Bill in the House of Commons, pointing out the desirability of including meteorology or weather study in the schedule of subjects. Mr. Collings had replied most cordially accepting the suggestion, and expressing the hope that the Bill would become law.

The President then referred to the forthcoming Franco-British Exhibition at Shepherd's Bush, and said that the Society was exhibiting in the Science Section. Amongst the exhibits it was hoped that there would be a complete Climatological Station at work in the grounds. There was no difficulty in finding the station, but to show it at work would require the services of observers to take the observations punctually at 9 A.M. and 9 P.M. He trusted that several Fellows would come forward willing to take these, for, say, a fortnight at a time, to share the work with those who had already promised. Observations would have to go on from May 15 till about the end of October.

The following communications were read :—

1. "REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1907." By EDWARD MAWLEY, F.R.Met.Soc., V.M.H. [This Report will be printed in the next number of the *Quarterly Journal.*]

2. "THE ANTICYCLONIC BELT OF THE SOUTHERN HEMISPHERE." By Colonel H. E. RAWSON, C.B., F.R.Met.Soc. (p. 165).

CORRESPONDENCE AND NOTES.

Meteorology and Agriculture.

At the Royal Agricultural Society's Show held at Newcastle-on-Tyne from June 30 to July 4, a very interesting and attractive exhibit was arranged by the Royal Meteorological Society in the Agricultural Education and Forestry Exhibition. The exhibit included a large number of diagrams relating to rainfall, temperature, sunshine, the influence of weather on crops, health, etc., and also a collection of photographs illustrating meteorological phenomena. Various patterns of self-recording and other meteorological instruments were also shown ; and as most of these were at work, the visitors could see at once the changes which were taking place in the weather.

The methods adopted for obtaining information on the meteorological condi-

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tions prevailing in the upper regions of the atmosphere were fully illustrated. A large kite with a meteorograph and also a ballon-sonde carrying a small meteorograph were suspended from the roof of the building. Diagrams exhibiting in a graphic manner some of the results obtained from Mr. Dines's observations were inspected with much interest, as these showed that the temperature decreases pretty uniformly up to a height of about 7 miles, above which there is practically little or no further change in temperature.

In a railed-off enclosure outside the Exhibition building, a fully-equipped Climatological Station was arranged with the various instruments in position, and at this station an address was given each day by Mr. W. Marriott on "Meteorology in Relation to Agriculture."

When the Prince and Princess of Wales visited the Show on July 1, they spent some time in the Royal Meteorological Society's Exhibit, and were greatly interested in the account of the upper-air investigations, and in examining some of the instruments and photographs.

Practical Open-Air Demonstration to Children.

As the result of conversation with some teachers attending the Royal Agricultural Society's Show at Newcastle-on-Tyne, Mr. Marriott promised to give an address to a number of school-children when he visited Keswick a week later.

By the kindness of Mr. A. Mitchell Dawson, arrangements were made by which the senior boys and girls, with their teachers, from several schools in the neighbourhood were able to be present in his beautiful garden on Friday morning, July 10. Mr. Marriott showed and described the various meteorological instruments used by Mr. Dawson in making his observations, and pointed out many of the results obtained from them. Under such favourable conditions, practical references were made to temperature, wind, clouds, rainfall, etc., which the children could easily follow.

Representatives were present from Brigham School, St. John's School, Crosthwaite School, and Braithwaite School, Keswick.

The Brontometer.

The late Mr. G. J. Symons, F.R.S., was from a boy greatly interested in thunderstorms, and he was for a long time engaged in devising an instrument to show the sequence of the various phenomena occurring during thunderstorms. He subsequently consulted MM. Richard Frères, of Paris, on the matter, and after deciding upon what the instrument was to do, and upon the scales required, he left the whole constructional details to them. The result was that in 1890 MM. Richard made for him an elaborate apparatus, which he called a "Brontometer," or Thunderstorm-measurer.

The following is Mr. Symons's description of the instrument:[1]—

"It is provided with endless paper, 12 inches wide, travelling under the various recording pens at the rate of 1·2 inch per minute, or 6 feet per hour. This is about 150 times faster than is usual in meteorological instruments, and enables the time of any phenomenon to be read off with certainty to a single second of time.

"The traces are made in ink by a series of seven Richard pens.

"The first pen is driven by the clock which feeds the paper, so that the time scale and the paper must go together. The pen usually produces a straight line, which serves as the base line for all measurements, but at 55 seconds after each minute the pen begins to go, at an angle of about 45°, one-tenth of an inch to the left, and at the sixtieth second it flies back to its original position.

[1] *Proceedings of the Royal Society*, **48**, p. 65 (1890).

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"The second pen is driven by one of Richard's Anemo-cinemographs, a name which they have given to a pattern of anemometer not yet known in England. The external portion has some resemblance to the ordinary windmill governor, but it differs from it in that the plates are curved, not flat; they are made of aluminium, and are so light that they have little momentum, and thus have a great advantage over cups, which run on for many seconds after the wind force has decreased or ceased. The fans make one revolution for each metre of wind that passes, and send an electric current to the brontometer, where it acts on an electro-magnet, and tends to draw this (2nd) pen towards the left; but a train of clockwork is constantly tending to draw the pen to the right, the joint result being that the pen continuously shows, not the total motion (as is the case with most anemometers), but the actual velocity almost second by second. It does this certainly with an error of less than five seconds, for the fans will stop dead in less than that time, and the clockwork train will bring the pen from indicating a velocity of 70 miles an hour to 20 miles an hour in three seconds, and down to a dead calm in seven seconds. The trace will thus resemble that of a pressure anemometer, but with a much more open scale than was ever before available.

"The third pen is actuated by a handle, and can be set at zero or at 1, 2, 3, or 4 spaces from it. The author's original idea was, partly by watching a storm-rain-gauge, and partly by estimation, to decide on the intensity of the rain and to indicate that intensity by moving the pen further and further from zero as the fall becomes heavier. Experience alone will show whether that is, or is not, superior to moving it one step for each $\frac{1}{100}$th of an inch of fallen rain, which can be done by making a Crosley rain-gauge send a current into the room where the brontometer is placed, and strike a bell there. In a heavy storm there will, however, be so much for the observer to do, that very probably count would be lost. It may, therefore, be necessary to make it act automatically.

"The fourth pen is actuated somewhat like a piano. On the occurrence of a flash of lightning, the observer presses a key, the pen travels slightly to the right, and flies back to zero. Referred to the automatic time-scale, this gives, to a second, the time at which the key was depressed.

"The fifth pen is similar, but, being intended to record the thunder, the observer will continue to hold down the key until the roll is inaudible. The time of the departure of this pen from zero will evidently be later than that for the lightning by the time-interval due to the distance of the flash, and possibly something may be learned from the accurate record of the duration of the thunder.

"The sixth pen is similar to the third, and is intended to record the time, duration, and intensity of hail.

"The seventh and last pen is devoted to an automatic record of atmospheric pressure. As the rapid motion of the paper, which is indispensable for studying the details of a thunderstorm, has enlarged the time-scale more than a hundredfold, it was imperative that the barometric scale should itself be greatly enlarged. But the range of the barometer in London is more than $2\frac{1}{2}$ inches, and no enlargement less than ten times the natural (mercurial) scale would be of any use; hence a breadth of 25 inches of paper would be necessary, unless some mode of shifting the indication could be devised.

"Several plans were tried, but finally a modification of Richard's statoscope has been adopted, which is so sensitive that it will indicate the opening or shutting of a door in any part of the house, gives a scale for 30 inches for each mercurial inch (*i.e.* about three times that of a glycerine barometer), and yet only requires 4 inches breadth of the brontometer paper. Without entering into

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all the details of construction, it is desirable to explain the general principle, and its application. As it was essential that the apparatus should record accurately

THE BRONTOMETER.

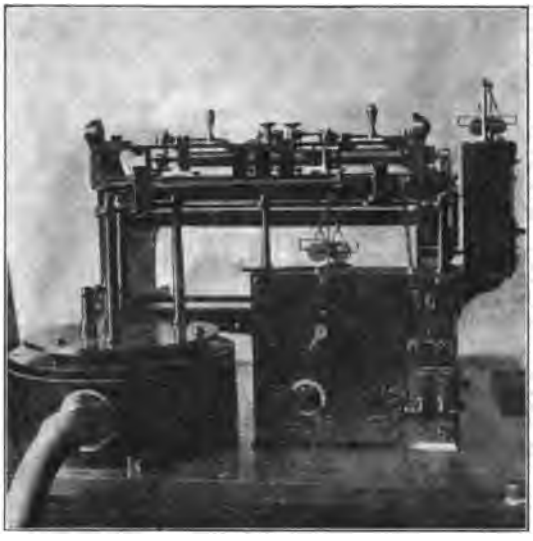


FIG. 1.—Front View.



FIG. 2.—Top View.

to 0·001 inch of mercurial barometric pressure, it was evident that friction had to be reduced to a minimum, and considerable motive power provided. This is done by placing in the base of the brontometer a galvanised iron chamber,

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which contains about 3½ cubic feet of air; on the upper part are a series of elastic chambers, similar to the vacuum boxes of aneroid barometers, but much larger.

"When the instrument is to be put in action, these chambers are connected with the large air-chamber, and a tap is closed which shuts off communication with the external air. Any subsequent increase, or decrease, of atmospheric pressure will compress or allow to dilate the air in these chambers, and the motion of the elastic ones produces that of the recording pen.

"Obviously, any large change in the temperature of the confined air would vitiate the readings; but (1) the instrument is not required to give absolute, but merely differential, values; and (2) the influence of the changes of temperature is greatly reduced by the chamber being surrounded with 4 inches thick of non-conducting material, besides nearly 1 inch of wood outside of it. The change of temperature in a room, and during the short time that the statoscope will be worked without resetting to zero (*i.e.* without opening the tap), has not hitherto produced any measurable effect."

The Brontometer came into my possession about two years ago. As I have no facilities at my house at West Norwood for putting up the Anemo-cinemograph, no wind records are made on the instrument.

I use the third pen for hail, and the sixth pen for rain—that is, transposing the records from those mentioned by Mr. Symons.

Reproductions from photographs of the instrument are given on page 209.

Fig. 1 is a front view of the upper part, which is fixed to the top of the wooden case containing the large air-chamber. The clock which feeds the paper is on the right. The case containing the elastic chambers of the statoscope is on the left-hand side. The tubing connecting this with the air-chamber below is seen in the lower corner. The clockwork for the Anemo-cinemograph is to the right of the statoscope case. On the top of the instrument will be seen the handles for moving the hail and rain pens, and also the keys for the lightning and thunder pens.

Fig. 2 is a view of the top of the instrument. This shows the position of the various pens as they pass over the endless paper.

I have not had many opportunities of using the Brontometer, as I am often away at the critical time—and thunderstorms do not come on "to order," —but such records as have been obtained have been of great interest. The thunderstorm which occurred on June 4, 1908, was not only a very severe one, but it afforded almost exceptional opportunities for obtaining records on the Brontometer of the various phenomena accompanying the storm. The particulars of this thunderstorm are given in a separate note.—Wm. Marriott.

Brontometer Records at West Norwood, June 4, 1908.

As the thunderstorm on Thursday evening, June 4, at West Norwood was of such an intense character, I think it may be of interest to give some particulars about it.

The weather during the day had been very hot and close, the *maximum* temperature being as high as 84°·7. Thunder was heard in the afternoon from about 2.40 to 3.10. A fresh storm came on about half-past 5, when distant thunder was heard. This storm gradually developed, and was most intense between 6.10 and 6.40. It continued till 7.30. After an interval of about a quarter of an hour another storm came on at 7.44, and continued till 8.30.

As I arrived home soon after 5.30, I got the brontometer to work, and so was able to obtain a record of the various features of the storm.

Ninety-eight flashes of lightning were observed in 28 minutes between 6.11 and 6.39. No records of lightning were taken from 6.39 to 6.45 owing to a fresh supply of ink being required to be put into the pen, but 63

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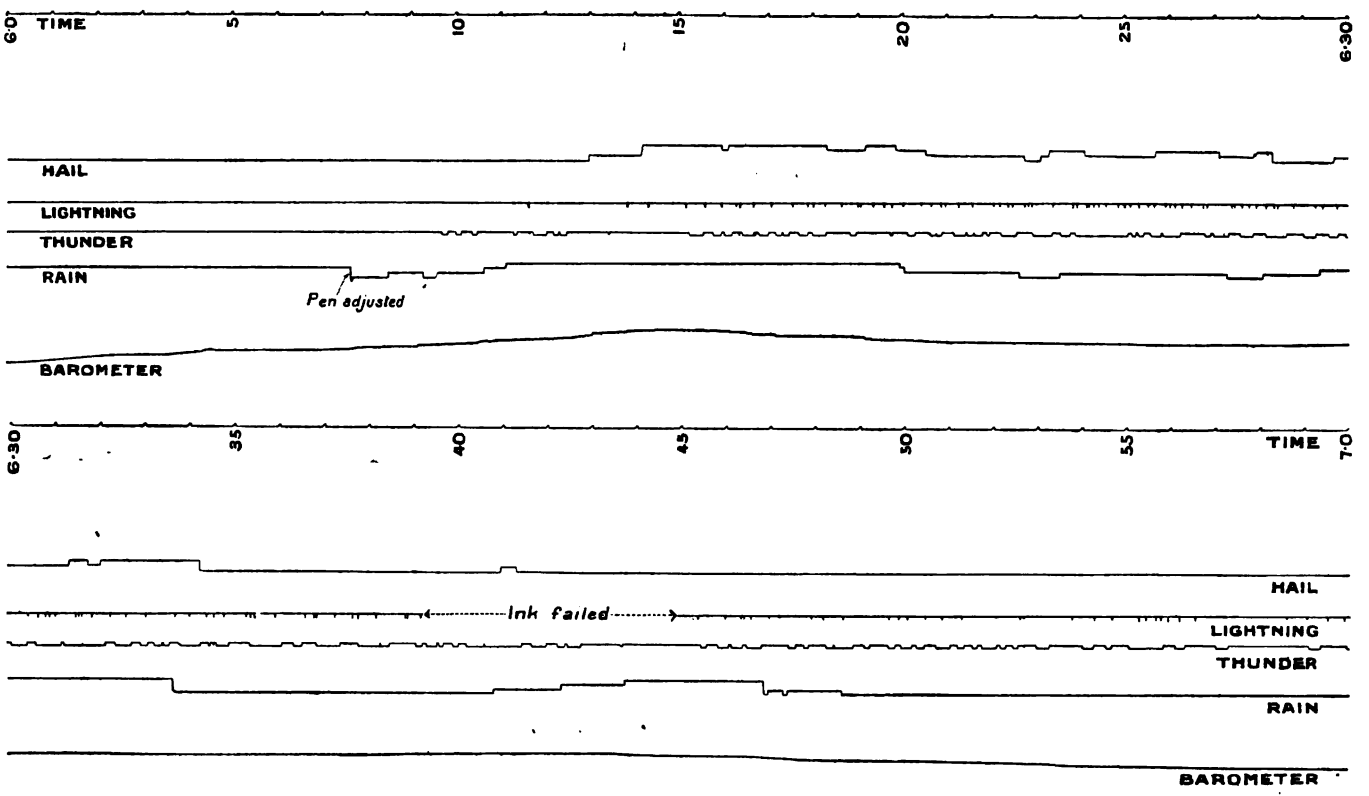


FIG. 3.—Brontometer Record at West Norwood, June 4, 1908.

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flashes were observed between 6.45 and 7.30. Many of the flashes were of a brilliant character, and were mostly of the "flickering" or "repeating" type.

I recorded 123 peals of thunder between 6.10 and 7.30. There were probably considerably more, but it was most difficult to distinguish between the individual peals, as before one had ceased another or more would have been heard. The longest duration of the rumble of an individual peal of thunder was 70 seconds.

Rain fell from 6.8 to 6.33 and from 6.41 to 6.48. It was extremely heavy during most of this period. Hail also fell from 6.13 to 6.34, the hailstones being larger than, and somewhat similar in shape to, big-sized acid-drops. The intensity of the rain and hail may be gathered from the fact that 1·14 in. fell in 33 minutes.

The barometer began to rise at 5.58, and reached its highest point when the hail began. It then fell slightly from 6.20 to 6.30, after which there was a further slight rise till 6.43, when the pressure gradually slackened till 7.5, and then remained stationary.

A reproduction (on a reduced scale) of the record from 6.0 to 7.0 is given in Fig. 3 (p. 211).

During the last storm 39 flashes of lightning were observed and 39 peals of thunder were heard between 7.44 and 8.29. Rain commenced falling at 8, and continued till after 9 o'clock. The rainfall during this storm amounted to ·15 in.—Wm. Marriott.

The Thunderstorms of June 1 to 4, 1908, at Epsom.

The first week in June, marked by an excess of high day and night temperatures, was noteworthy for the occurrence of a series of severe thunderstorms. On June 1 a sharp thunder shower took place at 5.45 A.M., distant rolling thunder being heard to the west at 6 A.M. After a warm day, with a shade maximum of 79°·8, a thunderstorm came up from the south and south-west towards 8.40 P.M. Very vivid fork and sheet lightning in the south, south-west, and west, accompanied by loud rolling thunder, occurred between 8.50 and 9.30 P.M. At 9.30 P.M. a dust-storm of considerable extent arose, dust in whirls and eddies being carried up spirally to a considerable height. At 9.40 P.M., on the commencement of the rain, a wind-squall attaining gale force passed from south-west to north-east, causing in its track extensive damage to timber, large trees being rooted up and blown down in a direction towards east and north-east. The storm passed the zenith at 9.45 P.M., working away in a northerly direction. The final termination of the storm was not reached until near midnight. The rainfall from 9.40 to 10 P.M. was 0·70 in. The barographic trace marked a sharp jump in pressure from 29·80 in. to 29·87 in. shortly after 9.30 P.M. Further thunderstorms of a sporadic character took place at 1.30 and 2.45 A.M. on the 2nd.

On June 3, after a very warm day, the shade maximum attaining 80°, a brilliant display of sheet lightning was visible in the south, south-west, and west between 10 and 11.30 P.M., when a thunderstorm moved up rapidly from the south-west, prevailing to 12.45 A.M. on the 4th. On its original track this storm would have crossed the zenith, but its course was changed by the influence of the high ground of the North Downs, and it passed south-east. Rain amounting to 0·05 in. fell between 12.25 and 12.35 A.M. At 1.15 A.M. on the 4th a further heavy storm came up from the south-west and west, a magnificent display of fork lightning being the prevailing feature, flashes varying between six and ten per minute being of frequent occurrence and of dazzling brilliance. The accompanying thunder was of a marked booming

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nature with a long roll; the storm was practically continuous till 3 A.M., remaining apparently stationary in the west and south-west for an hour and a quarter and then receding. No rain fell. A sharp drop in pressure occurred at 2 A.M. from 30·00 in. to 29·95 in. No reduction in temperature was exercised by the storm during the early morning hours of the 4th, the succeeding day being intensely hot, with a shade maximum of 83°·3. A cloudless sky prevailed till 2.30 P.M., when thunder clouds (cu-nim) came up from the north, accompanied by thick haze. From 4.15 to 5.30 P.M. distant thunder was heard in the east and south-east. At 5.45 P.M thunder clouds were visible in the north, north-east, and south-east, south-west, west, and north-west, a very heavy thunder-storm being noticed working up from north-west and west. Fork lightning accompanied by loud rolling thunder commenced at 6 P.M., the wind blowing in hot gusts from North and North-east. A very heavy fall of hail, lasting four minutes, took place at 6.15 P.M., the landscape being temporarily blotted out by the falling hail, and the ground covered as with a white sheet. The hailstones caused considerable noise in their descent and were of varied form and size, the majority egg-shaped (about equal to a blackbird's egg), others more or less square with ragged edges, whilst several pieces of ice with a rime coating were picked up. When split open the stones had a nucleus of clear ice; many were of considerable size owing to the agglomeration of several stones. Torrents of rain commenced on the cessation of the hail at 6.19 P.M., continuing till 7 P.M., extensive flooding taking place owing to the drains being choked; the roads leading off the Downs were converted into running torrents. The storm passed the zenith at 6.30 P.M. on a south-east course, vivid fork lightning and severe thunder being almost continuous. The end of the storm was reached at 7.30 P.M. Temperature at 6 P.M. was: Dry bulb 75°, wet 69°; and at 7.30 P.M., dry 65°, wet 64°. The barograph showed a sudden increase in pressure about 6.15 P.M., 29·87 in. to 29·92 in. The rainfall from 6.15 to 7 P.M. was 0·90 in. Towards 7.45 P.M. a second storm came up from the north and north-east, dense yellow gloom and a thick mist prevailing. A further display of vivid fork lightning and loud cracks of thunder lasted to 8.45 P.M., the storm passing in an easterly direction. The rainfall from 8 to 8.10 P.M. was 0·31 in.

A marked reduction in temperature was experienced in the rear of the storms, the exposed thermometer on the grass falling to 29°·8 on June 7.—SPENCER C. RUSSELL, *June* 10, 1908.

Lakeland Sayings about Weather.

The natives of Cumberland and Westmoreland have an extraordinary range of local expressions referring to the state of the weather, partly, perhaps, because the Lake District gets more than its share of rainfall, and numerous shades of meaning have from time to time arisen to meet the very variable conditions of the weather in that part of the country. A few samples are given below. It's "spittin' a laal bit," refers to a few drops which will probably soon be over. It "mizzles and rains" betokens a condition of things equivalent to a mild Scotch mist. It "hadders and rains," is equivalent to showers. "Nobbut a sup o' fell rain," purely local rain in the region of the fells is not considered a great evil. But when there is a "gert pash," a tremendous downpour is clearly meant. It is rather paradoxical to remark it's "fine an' wet," a reference to really heavy rain. By old-fashioned folk extremes are called "cruel het" and "cruel cauld." "Clashy Brough Hill weather" is almost proverbial, so often does a storm occur about Michaelmas, when this great fair of the North is held. "Glisy" applies to a day when the sun comes out in fitful gleams very brightly, and is next quickly overclouded—not a very favourable sign. "Eh, we're hevin' gran' growy weather," the Cumbrian

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farmer exclaims with delight when gentle showers come on a warm day. "It's ter'ble hask wedder," is another localism. "Hask" means harsh, rough, penetrating, all rolled into one, and specially applies to the East wind, which is at its worst when Cross Fell has "t' Hellum" on—*i.e.* the Helm wind. Lightning is most frequently referred to as "fire"—*e.g.* "t' fire was summat awful." A fall of snow which appears likely to be followed by still worse weather is called a "feeding storm."—*Penrith Observer*, June 23, 1908.

The Rain-tree of Queensland.

Amongst the last parcel of produce received at the City office of the Queensland Government, 73 Basinghall Street, are some pods of the "rain-tree" (*Pithecolobium Samam*), an importation into the Colony from Peru. It is a valuable shade tree in tropical pastures. The name of "rain-tree" is given because so great is the volume of distillation of moisture that the ground is wet under its branches.

Relation between the Weather and the Flowering of Fruit-trees.

In a paper read before the Royal Statistical Society in January 1907, Mr. R. H. Hooker drew attention to the correlation of the weather and the crops, and pointed out that an examination of the meteorological statistics and of the returns of the produce of crops suggested that the yield was influenced not merely by the character of the weather during the later stages of growth, but also during seed-time. Some similar conclusions in regard to the flowering of fruit-trees have been arrived at by Mr. E. P. Sandsten, of the Wisconsin Agricultural Experiment Station (*Bulletin*, No. 137). He points out that the time of flowering in the spring of a given variety of fruits is dependent upon a number of causes or conditions, chief among them being, first, the number of positive temperature units received in the spring preparatory to flowering; second, the stage of development of the flower-buds as dependent upon the climatic conditions of the summer and autumn preceding the flowering; third, the fruiting of the trees, whether light or heavy, the year previous to flowering; fourth, the soil conditions, and the amount of plant food present in the soil; and fifth, the individual characteristics and state of health of the tree or plant. From the data given in the *Bulletin* it would appear that there is but little relationship between the time of flowering and the temperature in the spring up to the time of flowering, while there appears to be considerable evidence that the temperature and other climatic conditions during summer and autumn preceding flowering have much to do with the time of flowering.—*Journal of the Board of Agriculture*, March 1908.

Icebergs of the Southern Hemisphere.

On the *Monthly Meteorological Charts of the Indian Ocean* for April 1908, some particulars are given respecting icebergs in the southern hemisphere. It is stated that icebergs occur irregularly, and they vary very considerably in size and number. For years in succession icebergs, and occasionally field ice, will be seen by ships traversing the Southern Ocean southward of Cape Horn and the Cape of Good Hope. Afterwards a whole decade may elapse before similar conditions are experienced. During the first six years of the period selected for this discussion, 1885 to 1907, icebergs were scarce in all the Southern Ocean within the limits of navigation; but from the close of 1891 up to the latter months of 1895, there were numerous reports of icebergs and ice-islands in great numbers and of phenomenal magnitude. There was also much field and drift ice. Between 1896 and 1905, however, there were very few reports of ice of any kind over the Southern Ocean. In 1906 a considerable amount was met with near Cape Horn; and this appears to have drifted north-eastward as far as the meridian of Cape Leeuwin in some instances.

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Southern icebergs are formed along the seaward edge of the Antarctic ice-cap; but whether they are broken off the water-borne extremities of glaciers protruding into the sea, as is the case with Arctic bergs, or whether they are simply wrenched from the ice-cap itself under the influence of seismic disturbances in the vicinity, remains yet to be proved. Once adrift from its place of origin an iceberg or an ice-island follows the path of least resistance, which coincides with the resultant of such forces as ocean-stream, drift-current, sub-surface current, and prevailing wind.

Icebergs have been seen in close proximity to the Cape of Good Hope in January and in August, and near Cape Leeuwin in January, but the northernmost ice ever met with in the Southern Ocean appears to have been that reported by the master of the barque *Dochra* on April 30, 1894, when in 26° 30′ S., 25° 40′ W. The vessel passed close to the remnant of an iceberg, which was 4 ft. high, 12 ft. long, and 4 ft. wide, under very favourable conditions for observations. The sea was smooth; the time was 10 a.m., and the weather was fine. Icebergs were also seen exceptionally far to the westward in comparatively low latitudes in 1893 and 1894. In June 1893, the s.s. *Milton* passed one in 45° S., 60° W.; and three days later the s.s. *Titania* sighted a berg apparently aground in 44° S., 59° E., which was 250 ft. high and 2 miles in length. Twelve months later H.M.S. *Garnet* passed an ice-island estimated to be 10 miles long, which similarly appeared to be aground, in 46° S., 61° W., about 330 miles north of the Falklands. These three instances show that it is unsafe to assume that the passage between the Falklands and the mainland is always free from ice.

In April 1892, the *Cromdale*, in 46° S., 36° W., was in the presence of innumerable bergs, one of which was 1000 ft. high as reported personally to the Meteorological Office by Captain Andrew on arrival in London. At daylight she was discovered to be standing into a horse-shoe shaped bay which had been hollowed out of one side of an ice-island of awe-inspiring magnitude. Vertical icy cliffs, over 300 ft. high, were on either side, and right ahead; and at least 50 peculiarly opaque bergs were adrift in this bay. Eventually Captain Andrew succeeded in beating out into open water without mishap. This peculiar form of berg is not by any means unique, and the fact should be remembered by seamen. In January 1893, for example, the ships *Wasdale* and *Stracathro* were in company in 47° S., 42° W. One day at sunrise they found themselves in an iceberg's horse-shoe shaped bay. It was 20 miles long, 4 miles across at the entrance, and increasing to a width of 20 miles in the middle area. Dampier, in his *Voyages*, has described just such an ice-island. Throughout the five months ended April 1855 there was probably the largest ice-island on record drifting about between 44° S., 28° W., and 40° S., 20° W. This danger was hook-shaped and had a height of 300 ft. Its longer shank stretched 60 miles without a break, and the shorter was 40 miles long. Between these promontories of ice was a bay 40 miles across. Three vessels became embayed, under the mistaken idea that they were running between two huge parallel ice-islands, and one of them was wrecked. The *Great Britain* coasted along a side of this danger for 50 miles. In June 1892, the *Duntrune*, going ten knots, collided with a large berg in 47° S., 38° W. Her bowsprit was broken short off, her foretopmast came down on deck, her bows were stove in, and the sea poured into the forecastle. At daybreak this berg was found to be 300 ft. high, and it stretched north-east and south-west from horizon to horizon. About the same date, in 54° S., 51° W., the *Wellington* collided with a berg, and was compelled to put into Rio Janeiro for the necessary repairs. Early in the month the *County of Edinburgh* passed numerous bergs in 45° S., 37° W., ranging from 200 ft. to 900 ft. in height; and, not far remote, the

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Stanmore was encircled by bergs some of which were 5 miles long and flush with the water. Such low masses of ice are especially dangerous; as they can only be discerned by the breaking of the sea over them. In April 1893, in 49° S., 51° W. the *Brier Holme* was surrounded by bergs, some of which had an altitude of 500 ft. to 1000 ft.; and the *Charles Racine* sighted a berg, 50° S., 52° W., which was 1000 ft. high and "several miles in extent," thus confirming the report from the *Brier Holme*.

During June 1906, a number of very large bergs were seen in the vicinity of Cape Horn. Between 58° S., 58° W., and 58° S., 68° W., the *Monkbarns* sighted a tabular berg which was 200 ft. high and 5 miles long, and another 200 ft. by 3 miles long. The *Ascensione* reported one 600 ft. high and 6 miles long, and probably aground.

In May 1892, the *Strathdon*, Captain A. T. Wills, was surrounded by icebergs in 45° S., 25° W. They were of enormous size, and she narrowly escaped collision with one, during the prevailing fog, which was at least 1000 feet high. The only opening seemed scarcely wide enough for the barque to pass through, and her yards almost touched the ice on either hand as Captain Wills stood boldly out for the open water. Next day the vessel sailed 40 miles along one side of an ice-island which had an altitude of from 800 ft. to 1000 ft. In April 1895, the *Lowther Castle* was similarly surrounded by icebergs, one of which was 635 ft. high by sextant, in 45° S., 25° E., and she had very remarkable escapes from collision with one or other of these dangers during the ten days ice was in sight on her way east. About the same time the *Earnock* fell in with a berg in 46° S., 20° E., and for several days she sailed between long rows of icebergs. At one instant not fewer than 100 were in sight from the barque's deck; and altogether she must have passed over 900, some of which were 600 ft. high and 3 miles in length.

RECENT PUBLICATIONS.

About the Weather. By MARK W. HARRINGTON. New York, 1907. 8vo. xx + 246 pp.

This is one of Appleton's "Home Reading Books," and is consequently written in a very simple style. The author is a master of his subject, as he was for some years the head of the U.S. Signal Service. In the Preface he says: "In the theory of education, which above all aims to be practical, in selecting branches of instruction that are best fitted to be turned to account in life and experience, a study of the art of forecasting the weather must naturally hold a high place: and, indeed, in any system of education, few fields of scientific investigation offer more interesting and valuable results in teaching close and discriminating observation of nature, and in reasoning out and drawing logical conclusions from given premises, than does this study."

The following extract from the chapter on "General Storms, Cyclones, or Lows" will give an idea as to the style in which the book is written:—

"The most remarkable discovery in the modern study of the weather is the cyclone. By this word is meant, not necessarily a furious destructive storm, but only a circular mass of air—a flat, thin vortex, shaped like a wafer, and having a system of internal motions of its own. These motions may be so intense as to be very destructive, but nine times in ten the cyclone is a very gentle creature—in some cases so gentle, that though it passes over our heads, it requires close observation and delicate instruments to detect it. It is not

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once in a hundred times that a cyclone does any damage to man, even when we count an occasional stroke of lightning. The word cyclone, however, is so frequently misunderstood that meteorologists generally use others, except when they write for their fellow students of the weather. They often call these masses of air general storms, because they are great disturbances of the atmosphere, and therefore are storms in a proper sense of the word, though not always in the popular sense. To avoid the misapprehension that the word storm creates, meteorologists often use the word 'low' as a substitute for 'cyclone' or 'general storm,' because it has no evil popular associations with it. And this word is appropriate, for it expresses the state of the barometer in a cyclone. Besides, this is the word used on the weather map to mark the centre of the cyclone.

"The cyclone appears on the map as an area of low pressure. Around the centre the isobars are closed up, enclosing an area or island of low pressure. The enclosing isobars are usually nearly circular, but sometimes oval or even irregularly elongated. When they are so elongated that a projection or trough extends towards the equator, they are likely to develop a series of local storms of great interest."

Climate. Considered Especially in Relation to Man. By ROBERT DE COURCY WARD, Assistant Professor of Climatology in Harvard University. With Illustrations. London: John Murray, 1908. 8vo. xv + 372 pp.

The author states that this work is based on lecture-notes which have been accumulating for the last ten years. It does not attempt to present any very new or original material, but it does aim to co-ordinate and set forth clearly and systematically the broader facts of climate in such a way that the general reader, although not trained "in the technicalities of the science," may find it easy to appreciate them. At the same time, the needs of the teacher and student have been kept constantly in mind, and the subject-matter has been arranged in such a way as seems best to adapt it for purposes of thorough study.

The general scope and purpose of the different sections in *Climate* are as follows. The Introduction is essentially a very condensed synopsis of the first six chapters of Hann's first volume, *Handbuch der Klimatologie*, with the addition of some other matter. Chapter I. gives a sketch of the classification of the zones. Chapters II. and III. give a brief summary of the general climatic types which result from the control of land and water, and of altitude, over the more important elements of climate. Chapters IV., V., and VI. are intended to give an outline of the climatic characteristics of the zones in a simple and vivid form, with the least possible use of tabular matter. For further general information on this subject, reference may be made to the world-charts of temperature, winds, cloudiness, rainfall, etc., given with greater or less completeness in the various text-books of meteorology and, very fully, in the *Atlas of Meteorology*. In Chapter VII. the attempt is made to give a survey of some of the relations between weather and climate and a few of the more important diseases. Little information on this subject is readily accessible to general readers. The life of man in the tropics, the temperate zones, and the polar zones is considered in Chapters VIII. to X. No attempt has been made by the author to discuss this subject in detail, but it has rather been his plan to pick out typical illustrations here and there, as suggestions. Many of the cases referred to will probably be familiar to teachers and students of geography, but the co-ordination of all the examples by climatic zones and by the natural climatic sub-divisions of these zones will, it is hoped, tend to give adequate emphasis to the climatic factor, which has hitherto been much

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neglected. The final chapter, on changes of climate, deals with historic and periodic, and not with geologic, changes. The last phase of the subject has been fully discussed in many books, while the former, which are of more interest to most persons, have received much less attention. The question of the influence of forests on climate, which many readers may expect to find considered in this book, is omitted because it is adequately taken up in Hann's *Handbook*.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of more general interest.

Abbe, C.—Comprehensive Maps and Models of the Globe for special Meteorological Studies. *Monthly Weather Rev., Washington*, **35**, 1907 (559-564).

Beadle, C.—Some Observations upon the Underground Water Supplies to the Thames Basin. *J. Roy. Soc. Arts, London*, **56**, 1908 (656-668).

Bentley, W. A.—Studies of Frost and Ice Crystals. *Monthly Weather Rev., Washington*, **35**, 1907 (512-516, 584-585).

Besson, Louis.—Sur les relations entre l'insolation et la nébulosité. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (73-76).

Bigelow, F. H.—Studies on the Rate of Evaporation at Reno, Nevada, and in the Salton Sink. *Nat. Geog. Mag. Washington*, **19**, 1908 (20-28).

Bigelow, F. H.—Studies on the Phenomena of the Evaporation of Water over Lakes and Reservoirs. *Monthly Weather Rev., Washington*, **36**, 1908 (24-39).

Blair, W. R.—The Change of Phase due to the Passage of Electric Waves through thin Plates and the Index of Refraction of Water for such Waves, with Applications to the Optics of thin Films and Prisms. *Bull. Mount Weather Obs., Washington*, **1**, 1908 (65-82).

Brodie, F. J.—The Weather during the Agricultural Year, 1906-1907. *J. R. Agric. Soc., London*, **67**, 1907 (289-296).

Carrington, P. M.—The Climate of New Mexico.—Nature's Sanatorium for Consumptives. *Trans. Amer. Clim. Assoc. Philadelphia*, **1907** (71-100).

Chree, C.—Magnetic Declination at Kew Observatory, 1890 to 1900. *Phil. Trans. Roy. Soc. London, A*, **208**, 1908 (205-246).

Church, J. E., jr.—Electric Disturbances and Perils on Mountain Tops. *Monthly Weather Rev., Washington*, **35**, 1907 (578-579).

Davis, F.—Climatology of Jacksonville, Fla., and Vicinity. *Monthly Weather Rev., Washington*, **35**, 1907 (566-572).

Die Witterung und phänologische Erscheinungen zu Tsingtau in dem Jahre vom Dezember 1906 bis zum November 1907. *Ann. d. Hydrog. u. marit. Met., Berlin*, **36**, 1908 (97-109).

Everdingen, E. van.—The Life and Work of Maurits Snellen (1840-1907). *Terrestrial Magnetism and Atmospheric Electricity, Baltimore*, **12**, 1907 (165-168 and pl.).

Exner, F. M.—Über eine erste Annäherung zur Vorausberechnung synoptischer Wetterkarten. *Meteor. Zeits., Brunswick*, **25, 1908** (57-67).

Fisk, S. A.—A Search for a Suitable Climate. *Trans. Amer. Clim. Assoc., Philadelphia*, **23**, 1907 (40-52).

Fremont-Smith, F.—The Effect of Florida Climate upon Acute and Chronic Disease. *Trans. Amer. Clim. Assoc. Philadelphia*, **23**, 1907 (117-126).

Gallenkamp, W.—Ein Vergleich der Auszeichnungen meines Regenautographen mit denen des Hellmann'schen und Sprung'schen Apparates. *Wetter, Berlin*, **25**, 1908 (28-33).

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Gawthrop, H.—Temperature Courses. *Monthly Weather Rev., Washington*, **35**, 1907 (576-578).

Gold, E.—The Relation between Wind Velocity at 1000 Metres Altitude and the Surface Pressure Distribution. *Proc. Roy. Soc., London, A*, **80**, 1908 (436-443).

Grossmann, Dr.—Die stürmischen Winde an der deutschen Küste vom 1. bis 12. Januar 1908. *Ann. d. Hydrog. u. marit. Met., Berlin*, **36**, 1908 (189-200).

Gulik, D. van.—Zur Statistik der Gewitter und der Blitzschäden in den Niederlanden. *Meteor. Zeits., Brunswick*, **26**, 1908 (108-115).

Hall, M.—The Jamaica Hurricane of October 18-19, 1815. *Monthly Weather Rev. Washington*, **35**, 1907 (564-566).

Hands, A.—Protection from Lightning. *J. Soc. of Architects, London, N.S.*, **1**, 1908 (250-260 and 4 pl.).

Henry, A. J.—The Winds of the Lake Region. *Monthly Weather Rev., Washington*, **35**, 1907 (516-520).

Hopkinson, J.—The Weather of the Year 1906 in Hertfordshire. *Trans. Herts. Nat. Hist. Soc., Hertford*, **13**, 1908 (221-240 and pl.).

Humphreys, W. J.—Note on the Movement of Moisture in Soils. *Bull. Mount Weather Obs., Washington*, **1**, 1908 (94-95).

Kähler, K.—Flächenhelligkeit des Himmels und Beleuchtungsstärke in Raume. *Meteor. Zeits., Brunswick*, **25**, 1908 (52-57).

Kassner, C.—Meteorologische Erdgloben. *Meteor. Zeits., Brunswick*, **25**, 1908 (49-52).

Kimball, H. H.—Pyrheliometer and Polarimeter Observations. *Bull. Mount Weather Obs., Washington*, **1**, 1908 (83-93).

Klengel, F.—Die Niederschlagsverhältnisse von Deutsch-Südwestafrika. *Wetter Berlin*, **25**, 1908 (54-57, 73-82).

Lancaster, A.—(Obituary Notice of). *Nature, London*, **78**, 1908 (33-34).

Lemoine, G.—Notice sur M. Janssen. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (41-42).

L(emoine), G.—La vie et l'œuvre scientifique de M. Antoine d'Abbadie. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (14-18).

Lockyer, W. J. S.—Beaded or Pearl Lightning Flashes. *Knowledge, London*, **5**, 1908 (53-54).

Maillet, E.—Les prodromes des crues dans le bassin de la Seine. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (10-13).

Marvin, C. F.—A Universal Seismograph for Horizontal Motion and Notes on the Requirements that must be satisfied. *Monthly Weather Rev., Washington*, **35**, 1907 (522-534).

Memery, M. H.—Température et taches solaires. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (43-51).

(Mill, H. R.)—The Geographical Distribution of Rainfall in the British Isles. Abstract of a Course of Lectures delivered before the Royal Geographical Society. *Symons' Met. Mag., London*, **43**, 1908 (45-50).

Nippoldt, A.—Bemerkungen zu neuen Karten des Feldes der täglichen Variation des Erdmagnetismus. *Meteor. Zeits., Brunswick*, **25**, 1908 (97-103).

Obermayer, A. von.—Die Ergebnisse der meteorologischen Beobachtungen auf dem Pic du Midi de Bigorre, 2859 m., und an der Fuss-Station Bagnère de Bigorre, 547 m., von 1894 bis 1903. *Meteor. Zeits., Brunswick*, **25**, 1908 (116-125).

P———, A.—Obituary Notice of Sir John Eliot, K.C.I.E., F.R.S. *Nature, London*, **77**, 1908 (490-492).

Peppler, W.—Die täglichen unperiodischen Luftdruckschwankungen. *Wetter, Berlin*, **25**, 1908, (49-51).

Petavel, J. E.—Investigation of the Upper Atmosphere. *Nature, London*, **78**, 1908 (56-57).

(Polis, P.).—Der Gewittersturm am 14. August 1906 im bergischen Lande. *Deutsches meteor. Jahrb., Aachen*, **1906** (14-17 and pl.).

Quin, J. T.—The Relation of the Movements of the High Clouds in Cyclones in the West Indies. *Monthly Weather Rev., Washington*, **35**, 1907 (510-511).

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Richter, C. M., and **McAdie, A. G.**—Phenomena connected with the San Francisco Earthquake. *Monthly Weather Rev., Washington*, **35**, 1907 (505-506).

Russell, H. C., 1836-1907.—(Obituary Notice of). *Proc. Roy. Soc., London, A.*, **80**, 1908 (lx-lxiii.).

Schott, G.—Die Wärmeverhältnisse auf dem Dampferwege zwischen der deutschen Bucht und New York, dargestellt in Isoplethen-Diagrammen. *Ann. d. Hydrog. u. marit. Met., Berlin*, **36**, 1907 (110-116).

Schulze, P.—Ludwig Friedrich Kämtz. *Wetter, Berlin*, **25**, 1908 (51-53, 82-87).

Sommerville, D. M. Y.—Sunset and Twilight Curves and Related Phenomena. *Proc. Roy. Soc., Edinburgh*, **28**, 1908 (311-337).

Stanton, T. E.—Wind Pressure. *Nature, London*, **78**, 1908 (79-82).

Steffens, O.—Ein neuer Windrichtungs-Autograph. *Ann. d. Hydrog. u. marit. Met., Berlin*, **36**, 1908 (208-211).

The Easter Snowstorm of 1908. *Symons' Met. Mag., London*, **43**, 1908 (65-74).

Trabert, W.—Die Luftdruckverhältnisse in der Niederung und ihr Zusammenhang mit der Verteilung der Temperatur. *Meteor. Zeits., Brunswick*, **25**, 1908 (103-108).

Turner, H. G.—The Collection and Storage of Water for Domestic Purposes in Connection with Farmhouses and Villages. *J. Inst. of Sanitary Eng., London*, **12**, 1908 (31-42).

Vanderlinden, E.—La déviation du vent entre 0 et 2000 mètres d'altitude. *Ciel et Terre, Brussels*, **29**, 1908 (58-63).

Waltham, W.—Die Wetterkunde in der Volksschule. *Wetter, Berlin*, **25**, 1908 (68-72).

Watt, A.—The Climate of the British Isles. *Scot. Geog. Mag., Edinburgh*, **24**, 1907 (169-186).

Wegener, K.—Über die zweite Fahrt des Ballons *Ziegler* nach England vom 1. bis 3. November 1907 in 40 Stunden. *Meteor. Zeits., Brunswick*, **25**, 1908 (67-73).

Wellam, F. C.—Report on the Climate, Natural History, and Disease Incidence of the Angola Highlands. *Trans. Amer. Clim. Assoc., Philadelphia*, **23**, 1907 (21-39).

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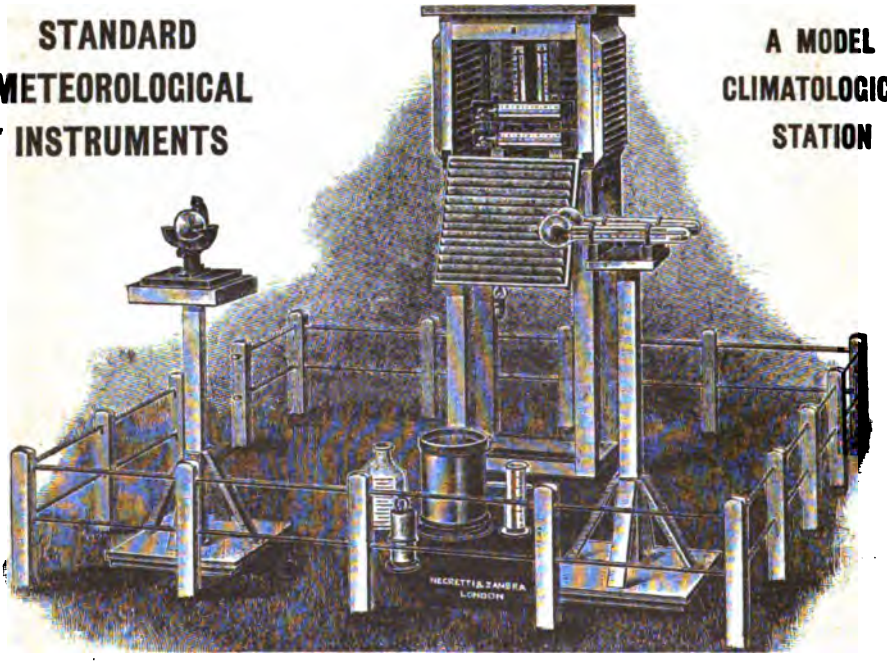
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THE DAWN OF METEOROLOGY.

BY DR. G. HELLMANN,

Professor of Meteorology at the University of Berlin, Director of the Royal Prussian Meteorological Institute, Honorary Member of the Royal Meteorological Society.

[A Lecture delivered before the Royal Meteorological Society, March 11, 1908.]

(Plate 3.)

FIRST of all I beg to return my best thanks to the President and Council of the Royal Meteorological Society for having been so kind as to invite me to deliver this evening a Lecture before the Society. Highly appreciating, as you know, your Society, the oldest one of the kind existing, I gladly accepted the invitation, and have chosen as the subject of my lecture a theme which has not yet been fully dealt with in this country.

I shall speak on the earliest evolution of meteorology, when our science was in its infancy; but before proceeding to do so, let me ask you to excuse any errors which I may commit in your tongue.

Meteorology as a science is young, but as a branch of knowledge very old, perhaps as old as mankind. Indeed, the beginnings of meteorology are to be found with the origin of human civilisation.

In those remote times, man living as hunter or agriculturist mostly in the open air was more influenced by and more depending on the weather than we are ourselves at present, and he was therefore forced to watch atmospheric phenomena. He did so, of course, not in order to study the atmosphere and to discover its laws, but to derive immediate advantages for himself. He was anxious to learn how to protect his house against the inclemency of the weather, how to foresee the best atmospheric conditions for his undertakings, or how to find out the most favourable climatic situations for his fields.

The experience of the more intelligent men in this respect was handed down, and at the same time augmented, from generation to generation, and formed very early an essential element in the knowledge of the people.

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It was the popular weather-wisdom which is still living nowadays and will never die. This weather knowledge soon assumed the form of short proverbs, or rather absolute rules, because thus they were easily committed to memory. Although a good many of these early weather-rules were based on the real observation of natural signs, such as winds, clouds, and optical phenomena in the sky, yet many of them arose out of false combinations and conclusions, and were, moreover, mixed with superstitious ideas which then pervaded all human thoughts.

It would, therefore, be wrong to imagine that the rich store of weather-lore found in the Bible, especially in the Book of Job, in the poems of Homer and Hesiod, that is, in writings of the eighth century B.C., originated then in Palestine or Greece. On the contrary, the familiarity of the people with the sayings and rules concerning the weather, revealed to us by these writings, show clearly that they must be considered even then as a primeval stock of culture. Indeed, there is every reason to believe that the origin of a great deal even of the modern weather-lore can be traced to its Indo-Germanic source.

In two instances I have succeeded in proving the great age of modern weather-lore, and it seems to me deserving of notice that in both cases weather-superstition is concerned, for it is notorious that nothing has such strong roots in the mind of the people as superstition.

You know well that people attribute a good deal of prognostic signification to the so-called "twelve nights" (or "twelve days"), which formerly were counted from the beginning of the year, but later, under the influence of the Christian Church, from Christmas. People believe that the weather of these twelve nights (or days) corresponds with that of the twelve months of the following year—indeed, a rather simple forecast of long range if it were true! This superstition is met in the whole of European literature back to the fifteenth century, and still earlier in many MSS. Also the venerable Bede mentions it; and the Byzantine-Greek work on agriculture, called *Geoponica*, which was collected in the sixth century A.D., tells us that even Democritus, in the fifth century B.C., was familiar with it in pretty much the same form. On the other hand, we learn from the Sanskritists that the old Indian or Vedic texts reveal the same belief in the twelve nights as a symbol of the following twelve months. But this superstition not only spread westwards with the Indo-Germanic race, it migrated also eastwards to China, where on New-Year's Day a custom is still in use which is based on the same Indo-Germanic conception.

Another superstition concerning the weather leads us to old Babylonia.

Many European chapbooks of past centuries, and a little Swedish book, *Sibyllæ Prophetia*, which is sold to-day at fairs, contain forecasts of the weather and fertility of the whole year deduced from the thunder heard in each of the twelve months. These "signa tonitrui" can be followed up in MSS. till the Middle Ages, and goes back apparently to the rich literature of thunder-almanacs or brontologies, in the composition of which in the fourth and fifth centuries even Byzantine emperors have taken part. In a similar chapter of the already cited Greek book *Geoponica* this doctrine is attributed to Zoroaster. Though this may not be the real author, yet his name indicates its

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Oriental origin. And, indeed, I found in the works of the Assyriologists—Sayce at Oxford and Lénormant in Paris—some translations of cuneiform tablets proving the Chaldaic origin of this superstition concerning thunder.

The state of meteorology in the old Babylonian culture, namely, three to one thousand years B.C., shows quite another character than it did in those primeval times in which the weather proverbs originated.

After having been formed into the beginnings of a learned profession by the priests, the atmospheric phenomena were brought by them into connection with the constellations of the heavenly bodies, and a complete system of consequences and combinations was established which gave rise to the Astro-Meteorology. It even formed an integral part of the Assyric-Babylonian religion.

Thanks to the memorable discovery by Sir Henry Rawlinson of the astrological cuneiform library of Assurbanipal, now preserved in the British Museum, and of which some parts have been deciphered quite recently by Mr. R. Campbell Thompson and Rev. Franz Xavier Kugler, S.J., we got for the first time a very interesting insight into the astro-meteorological system of old Mesopotamia, the existence of which system was often alluded to by the writers of antiquity, but which was never fuller explained.

The meteorological observations of the Chaldeans were apparently of a quite selective nature, referring above all to optical phenomena, especially to the halos. They distinguished clearly the small halo of 22° diameter, called "tarbasu," from the greater one of 45°, called "supuru." Besides, they paid much attention to clouds, winds, storms, and thunder. But a good many of these observations served more for a general prophecy of good and bad things, or omens, than for the forecast of the weather. All these predictions were addressed to the King, and contained at the end the authority, that is, the name of the astrologer, on whom they were based.

Let me give some examples :—

(Thompson, 98).—When a dark halo surrounds the moon, the month will bring rain or will gather clouds. When a halo surrounds the moon and Mars stands within it, there will be a destruction of cattle. Aharru will be diminished (it is evil for Aharru).

(Thompson, 248).—When a cloud grows dark in heaven, a wind will blow. From Nabu-ahi-iriba.

(Thompson, 253).—When it thunders in the day of the moon's disappearance, the crops will prosper and the market will be steady. From Ašaridu.

It seems to me interesting to point out that in the Vedic texts, especially in the commentary to the Samaveda, similar consequences are deduced from rare meteorological phenomena, but with this difference that here also the sacrifices prescribed for them are indicated. And you know that at Rome also all extraordinary natural phenomena were considered as *omina* and *portenta* which had to be expiated by the priests.

No meteorological theory has yet been discovered in the Babylonian tablets, of which, of course, only a small number has been preserved, and even a smaller number deciphered. But I was quite recently greatly

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surprised to find that the Babylonians had the windrose of eight rhumbs, and used already the names of the four cardinal points to denominate the intermediate directions; whereas it was till now generally supposed that we owe to Charles the Great, or perhaps to his learned monk Alcuin, who came from Yorkshire, this progress of the combination of the four principal winds to denote all others. That was indeed a great advance, for it is well known that in the Greek and Roman periods each wind had its peculiar name, a practice still in use amongst the Italian mariners in the Mediterranean.

The Babylonians counted the four cardinal points in the order South, North, East, West (*šutu*, *iltanŭ*, *šadu*, *amurra*), and by combining them with the word and (*u*), they formed e.g. *šutu u šadu* = South-east, *iltanu u amurra* = North-west, and so on.

From the Babylonians to the Greeks is a far cry, but there is also great progress from a meteorological point of view. It seems that the Greeks were the first to make regular meteorological observations, some results of which are still preserved, and that their great capacity for pure science induced them to establish meteorological theories

My first statement is not only proved by Theophrastus, who quotes several men in Asia Minor and Greece making meteorological observations, but also by the interesting fact that since the time of Meton, namely, since the fifth century B.C., in the so-called *parapegmata* (παραπήγματα), a kind of peg almanac fixed on public columns, the general data of the weather resulting from observations were exhibited. And as these weather-almanacs differed from town to town, it clearly follows that they were based on individual observations made in each district.

Here is an example taken from the *parapegma* of Geminos, whose book, entitled *Introduction to the Phenomena*, is of special value for this question:—

August 31.—The shoulders of Virgo are rising. The winds called ἐτησίαι cease to blow.
September 5.—Rising of Arcturus. South wind, rain, and thunder.
September 12.—The weather will likely change.
September 14.—Mostly fine weather for seven days, thereafter easterly winds.

I am able to show to you some fragments of such a *parapegma* found recently at Miletus, and now preserved in the Museum at Berlin (Plate 3, Figs. 1 and 2).

In the holes you can see in the marble stone little wooden pegs were put in order to fix the beginning of the year and the days, which gave rise to the name *parapegma*, to be derived from the Greek verb παραπηγνύναι = to fix into.

It is not surprising that in these *parapegmata* the observations of the wind prevail over all others, for they were of practical use to navigation and easily made. Also, the origin of the winds has always been a favourite subject of speculation among the Greek philosophers. In the epoch of Homer winds were still conceived as absolute beings like gods, whereas Anaximander of Ionia, who lived in the fifth century B.C., is the first to give a scientific definition of the wind, which is still valid. He says: ἄνεμον εἶναι ῥύσιν ἀέρος, the wind is a flowing of air.

It is therefore quite natural that the Greeks even at this early period

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FIG. 1.—Fragment of Parapegma.



FIG. 2.—Fragment of Parapegma.

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used wind-vanes, which represent the older meteorological instrument, and a most interesting example of it is preserved in the "Tower of Winds" at Athens. But I am inclined to believe that the principal purpose of



FIG. 3.

this architectural monument, which your Society has chosen by way of emblem, was not the observation of the direction of the wind. The tower stands on the market-place in the low town immediately at the foot of the high Acropolis, and is therefore too much sheltered (Fig. 3). It was, perhaps, rather a useful time-keeper for the people attending the

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market, since it contained a clepsydra, or water-clock, which was moved by the water of a still existing fountain in the neighbourhood bearing the same name κλεψύδρα. I suppose, therefore, that the architect, Andronikos Kyrrhestes, mostly for reasons of architectural beauty and harmony, combined with this poor-looking clock a more magnificent octagonal tower with artistic emblems of the winds. I am confirmed in my opinion by the fact that, according to Theophrastus, the astronomers and meteorologists of Athens avoided making their observations in the town, but preferred to go for this purpose to the top of Hymettos, which hill lies quite outside the town in an open situation.

At the time of the construction of the tower, namely, in the first century B.C., a great many wind-vanes were already in use; for a contemporary Roman writer, Terentius Varro, tells us that in Roman villas they were constructed in such a manner as to show the direction of the vane on a windrose fixed to the ceiling of the room ("ut intus scire possis").

Notwithstanding the great use made of the wind-vane, it has always struck me as curious that no Greek or Roman word for it has been handed down to us.

Soon after these earliest qualitative observations of the weather and direction of the wind we find the first quantitative ones, that is to say, the measurement of rain, in the first century A.D. It was made in Palestine, where the great influence of rainfall on the crops must have been fully appreciated at an early date, and the results of which observations are preserved in the Mishnah, a collection of Jewish religious books apart from the Bible. It seems to me most interesting to state that the amount of rainfall then considered as normal for a good crop corresponds pretty closely with that deduced from the modern observations made by Mr. Thomas Chaplin at Jerusalem, whence it can be inferred that the climate of Palestine has not changed. You know that the French scientist Arago came to the same conclusion mainly by phenological arguments.

Many of my audience will perhaps be astonished when I state that we are indebted also to antiquity for the first idea of a most important modern meteorological instrument. For, as I well know, most scientists are still of the opinion that antiquity achieved nothing concerning physical instruments and experiments. But the more we become acquainted with the scientific and technical literature of the Greeks and Romans, which at present is often the subject of study of philologists in preference to the classical authors, the more we learn their many positive results in this respect.

There are two physicists of special interest to us in this connection, namely, Philo of Byzantium, who lived in the third century B.C., and Hero of Alexandria, whose century is not yet settled, but who certainly lived after Philo and the great mathematician Archimedes, both being quoted by him. In the writings of these two physicists we find the description of an apparatus which represents the primitive idea of the thermoscope.

Philo's description in his work *De ingeniis spiritualibus* (On Pressure Engines), the Greek original of which is lost, only an Arabian and a Latin translation being preserved, will be made intelligible by Fig. 4. He says:—

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One takes a leaden globe of moderate size, the inside of which is empty and roomy. It must neither be too thin that it cannot easily burst, nor too heavy, but quite dry so that the experiment may succeed. Through an aperture in the top is passed a bent siphon reaching nearly to the bottom. The other end of this siphon is passed into a vessel filled with water, also reaching nearly to the bottom, so that water may the more easily flow out. *a* is the globe, *b* the siphon, and *g* the vessel. I assert, when the globe is placed in the sun and becomes warm some of the air inclosed in the tube will pass out. This will be seen, since the air flows out of the tube into the water, setting it in motion and producing air-bubbles, one after the other. If the globe is placed in the shadow or any other place where the sun does not penetrate, then the water will rise

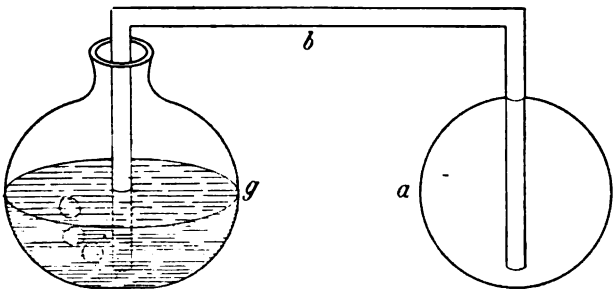


FIG. 4.

through the tube flowing into the globe. If the globe is again placed in the sun the water will return to the vessel, and *vice versa* . . . . The same effect is produced if one heats the globe with fire or pours hot water over it. . . .

Somewhat more complicated is the similar apparatus of Hero, to which he gives the name λιβάς, or drip (Fig. 5).

Now it happened that this book of Hero on pneumatics, which must have been widely distributed already in MS., was translated in the eighteen years between 1575 and 1592 no less than twice into Latin and three times into Italian. It was studied by Galileo, Porta, and Drebbel, and gave, about the year 1600, to all three men the idea of constructing a thermoscope, and to the last one also the impulse of making an experiment on the origin of the winds.

From this it appears there is an interesting connection between the science of two remote periods with an interval of time of more than 1800 years!

As I said before, the Greeks were also the first to start theories of meteorological phenomena. Indeed, since the time of the oldest philosophical school, that of Ionia, there are few Greek philosophers who were not interested in some branch of meteorology. This covered a wider field of research then than at present, embracing, besides meteorology in the modern sense, also a good deal of physical geography and astronomy, especially shooting-stars, meteors, and comets. The favourite meteorological subjects of speculation and research seem to have been the origin of the winds, the theory of the rain, including the regular inundation of the Nile, and the rainbow. A good many cosmological speculations were also put forward by the meteorologists which often

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proved false, and, considered from a practical point of view, in all cases rather useless, whence in the period of Socrates meteorology itself came into disrepute. A new word was coined—μετεωρολέσχης instead of μετεωρόλογος—in order to designate a mean babbling about sublime things. Aristophanes' comedy, *The Clouds*, seems expressly composed for the derision of these theorisers.

But notwithstanding, meteorology made some real progress in time, and reached such perfection a century later that the system established by Aristotle remained for nearly two thousand years the standard text-book of our science. To be sure, considered from a modern point of view, Aristotle's meteorology was antiquated long ago, but if you imagine yourselves back in those old times you will agree with me that his treatise

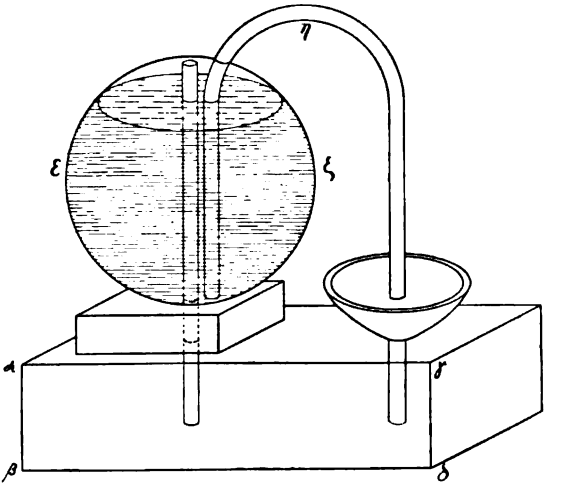


Fig. 5.

of meteorology—the earliest one existing—is an excellent piece of work, and well worthy of the greatest systematiser of all times.

I would go too far if I were to analyse here the merits and demerits of Aristotle's meteorology. It may be sufficient to say that his most distinguished successors, such as Theophrastus and Posidonius, have added but little to the perfection of his system, which, on the contrary, gave rise to innumerable commentaries and paraphrases. All text-books of meteorology issued on the Continent till the end of the seventeenth century are exclusively based on Aristotle, whereas, curiously enough, in England his influence was much less. If I except Duns Scotus, I do not know any British scholar who has written a commentary on the Meteorology of Aristotle, and even this one has quite recently been disputed. It is true, the number of treatises on meteorology published in Great Britain before 1700 is unusually small compared with that issued contemporaneously in Germany, Italy, and France, in Latin or the vernacular language.[1] Englishmen seem always to have been more

[1] Mr. G. J. Symons was of opinion that the earliest English book containing meteorological subjects was *The Kalender of Shepeherdes*, printed by Wynkyn de Worde in 1508. I can,

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inclined to make actual observations of the weather than to theorise upon it and to write systematic treatises on meteorology.

Among the Romans meteorology made but little progress, like all other sciences of no immediate practical value. Pliny, Seneca, and Lucretius do not add any remarkable fact or theory to the knowledge of the Greeks, and probably the same can be said of the lost writings of Nigidius Figulus and Suetonius Tranquillus. From Virgil we learn some new weather-proverbs originating in Italy, and a writer on agriculture, Columella, who owned a large estate near Cadiz in Andalusia, has left behind a *Calendarium Rusticum*, or rural calendar, with many interesting weather-observations made in that district.

The extensive colonial possessions of the Romans were, of course, suitable for advancing the conceptions of climatological differences of the countries. As the great military expedition of Alexander the Great to Inner Asia and India had brought to the Greeks the first knowledge of the monsoon winds, so the Romans were the first to point out the difference between the continental and maritime climate. Minucius Felix, a Christian writer from Africa, living in the second century A.D., says, concerning the climate of Great Britain, "Britannia sole deficitur, sed circumfluentis maris tepore recreatur," that is, freely translated, "Britain has little sunshine, but a mild climate on account of the warm sea-water flowing round it."

The barbarous state of Europe after the fall of the Western Empire was not adapted to the furthering of science, which was barely kept alive within the Christian Church. Yet the pursuit of meteorology never wholly ceased; for the Fathers of the Church, writing commentaries on the work of the seven days, the so-called Hexaëmeron, often took occasion, when dealing with the first day of the Mosaic Creation, to insert long elaborations on the atmosphere and its phenomena.

At the very beginning of the Middle Ages the great encyclopedists, such as Isidorus Hispalensis in Spain, the Venerable Bede in Great Britain, and Rabanus Maurus in Germany, were the first to devote more attention to meteorological questions, the interest in which must have

however, state that the first English printer, William Caxton, had previously issued in 1481, a book dealing with meteorology. It is the *Myrrour of the Worlde*, "translated out of frensche into English by me simple person Wyllm Caxton," the French original being the *Image du Monde*, composed in the thirteenth century. The last chapters of the "second book" are entitled: Ayer and his nature; clouds and rain; frost and snow; hail and tempest; lightning and thunder; winds; fire and falling stars.

But a really systematic treatise on meteorology was not published in England until the year 1563. This bears the curious title: *A Goodly Gallerye with a most pleasaunt Prospect into the garden of naturall Contemplation, to behold the naturall causes of all kynde of Meteors, as wel fyery and ayery, as watry and earthly*, etc., and was written by William Fulke, "Doctor in Divinitie." This small book in octavo was reissued with varying titles in 1571, 1634, 1639, 1640, 1654, 1655, and 1670, and so passed through more editions than any other English meteorological book. The author deals with the subject in a more popular than scientific manner.

English students mostly made use of the meteorological treatise written in Latin by the Belgian professor Libertus Froidmont (Latinised Fromondus), *Meteorologicorum libri sex* (Antverpiae, 1627, 4°), of which three editions were issued in England, namely, Oxford 1639, London 1656, and London 1670.

Other treatises on meteorology published prior to 1700 are the posthumous work of Edward Brerewood, *De Meteoris* (Oxford, 1631; third edition, 1637); *Natures Secrets, or the admirable and wonderfull history of the generation of Meteors . . .* by Thomas Willsford (London, 1658 and 1665); and a small *Treatise on Meteorology* by the Rev. T. Robinson (London, 1696).

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been considerable in England, for in the tenth century an extract of Bede's writings, concerning astronomy and meteorology, was made for the uninitiated in the Anglo-Saxon language, which is perhaps the earliest treatise on science written in a popular form. It contains chapters on the winds, rain, hail, snow, and thunder.

A general revival of studies took place at the end of the twelfth century, when the writings of Aristotle, among which was his Meteorology, came to the knowledge of the Western students by Latin translations made in Spain from the Arabian ones, not from the Greek originals. The imposing meteorological system of the great Stagirite again exercised a great influence on the writings of the scholars and on the teaching in the recently established universities, where, under the title "Meteora," regular courses and even exercises in meteorology were held. Albertus Magnus at Cologne wrote at this time his great meteorological works (*De Meteoris*, libri iv., and *De Passionibus Aeris*), paraphrasing chiefly those of Aristotle, but adding also the opinions of other authorities and his own remarks; and at the same time, or somewhat later, Vincent de Beauvais in France, Thomas de Cantimpré in Belgium, Ristoro d'Arezzo in Italy, Bartholomew Anglicus (or de Glanvilla) in England, incorporated the Aristotelian ideas in their encyclopedic works all bearing the general title, *On the Nature of Things* (*De Natura Rerum*).

But the firm and absolute adherence to the doctrines of the master, Aristotle, the denying of all that could not be found in his writings, rendered the scholastic meteorology so noxious to any real progress that it came into conflict with all new ideas. Notwithstanding, these forced their way by and by, and the beginnings of the modern experimental science are to be found just at that epoch when scholasticism had reached its highest point, namely, in the thirteenth century.

It is not yet definitely settled where the new experimental science took its origin—most likely contemporaneously in France and in England, where the two friends Pierre de Maricourt (Petrus Peregrinus) and Roger Bacon can be considered as the first great representatives of the new aims.

The former, a French nobleman and military engineer, is the author of the famous treatise on the magnet, and made many optical experiments like his English friend; and although both have not dealt with meteorology properly speaking—except the rainbow—yet their general influence must have been great on our science also. Roger Bacon's energetic opposing of the experiment to the argument—"argumentum non sufficit, sed experientia," he says in his *Opus Majus*—conduced naturally to the observing of atmospheric phenomena instead of only interpreting the writings of the ancients.

Thus the new aims advanced meteorological observations also, for which the ground was well prepared. As I have just shown, such observations were made in antiquity and never had wholly ceased, despite frequent and long interruptions. For the custom of the Roman historians to note in their annals the more important atmospheric phenomena, especially those necessitating sacrifices, was handed down to the chroniclers of the Middle Ages, whose chronicles became richer and richer in entries of the weather, till at the end of the thirteenth century these records are so replete with remarks on the weather that the character of the seasons could be traced back.

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And now the time is ripe for more systematic observations, and we find at Oxford William Merle, a Fellow of Merton College, to whom remains the distinction of being the first man in the Occidental world to keep a regular journal of the weather day by day. It embraces the years 1337 till 1344. The journal was wholly forgotten; but reading in an old volume of the *Philosophical Transactions* (1685), I came on a passage stating that such a journal of the weather is preserved at the Bodleian Library. I at once wrote to my late friend, Mr. G. J. Symons, asking him to look for this precious MS., and to publish it, if it should be found. And he did so. He published in 1891 the earliest known journal of the weather, kept at Oxford and later at Driby in Lincolnshire, where William Merle was Rector.

These recorded weather observations, of which I show as a specimen the months of November and December 1341 (Fig. 6), are not



FIG. 6.—Specimen of Merle's Journal, November and December 1341.

the original journal jotted down from day to day, or week to week, as time passed on. Had it been so there would have been far greater variation than there is in the size and character of the letters. The MS. represents only a résumé of the daily entries.

A close examination of the circumstances forces me to the conclusion that William Merle was induced to make regular observations by the desire to ascertain the correctness of the prognostics made by himself and his colleagues at Oxford where meteorology, or, more properly speaking, astro-meteorology, had been flourishing since the time of Robert Grosseteste, the famous Bishop of Lincoln. Merle himself has left behind two MSS. on the forecasting of the weather, and his contemporaneous Fellow of Merton College, John Eschendon (or Ashendon), whose name has been corrupted into Eschuid, completed in 1348 a voluminous treatise of astro-meteorology bearing the title *Summa judicialis de accidentibus mundi.* It was printed at Venice in 1489, and served in the sixteenth century as a text-book at the University of Vienna. The work is usually quoted in meteorological literature under the abbreviated title, *Summa Anglicana*, and is now extremely rare.

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When, eighteen years ago, the journal of William Merle was rediscovered, it seemed to stand all alone, since we had no knowledge of other observations made in England or abroad. But recently I have been able to find out a nearly continued sequence of series of such observations, and to prove that from the fourteenth to the middle of the seventeenth centuries, namely, till the invention of meteorological instruments, the weather has been regularly observed in many places in Central and Western Europe.

I had noticed that some copies of the large astronomical work, published in 1499 by Justus Stoeffler and Jacob Pflaum at Tübingen, *Almanach nova plurimis annis venturis inservientia*, containing ephemerides for the years 1499 to 1531, were full of meteorological entries written on the broad margins. This induced me to make systematic inquiry into copies of the work named containing such entries preserved in the great libraries of Germany, Austria, and Switzerland. The result of this inquiry was rather astonishing. No less than 123 different series of meteorological observations belonging to the fifteenth, sixteenth, and seventeenth centuries were dug out. Considering that this number of necessity represents but a small proportion, and concerns only some parts of Central Europe, we may safely presume that in the whole of Europe their number must have been far greater. Some of these early series of weather-observations are even corresponding ones, made by agreement.

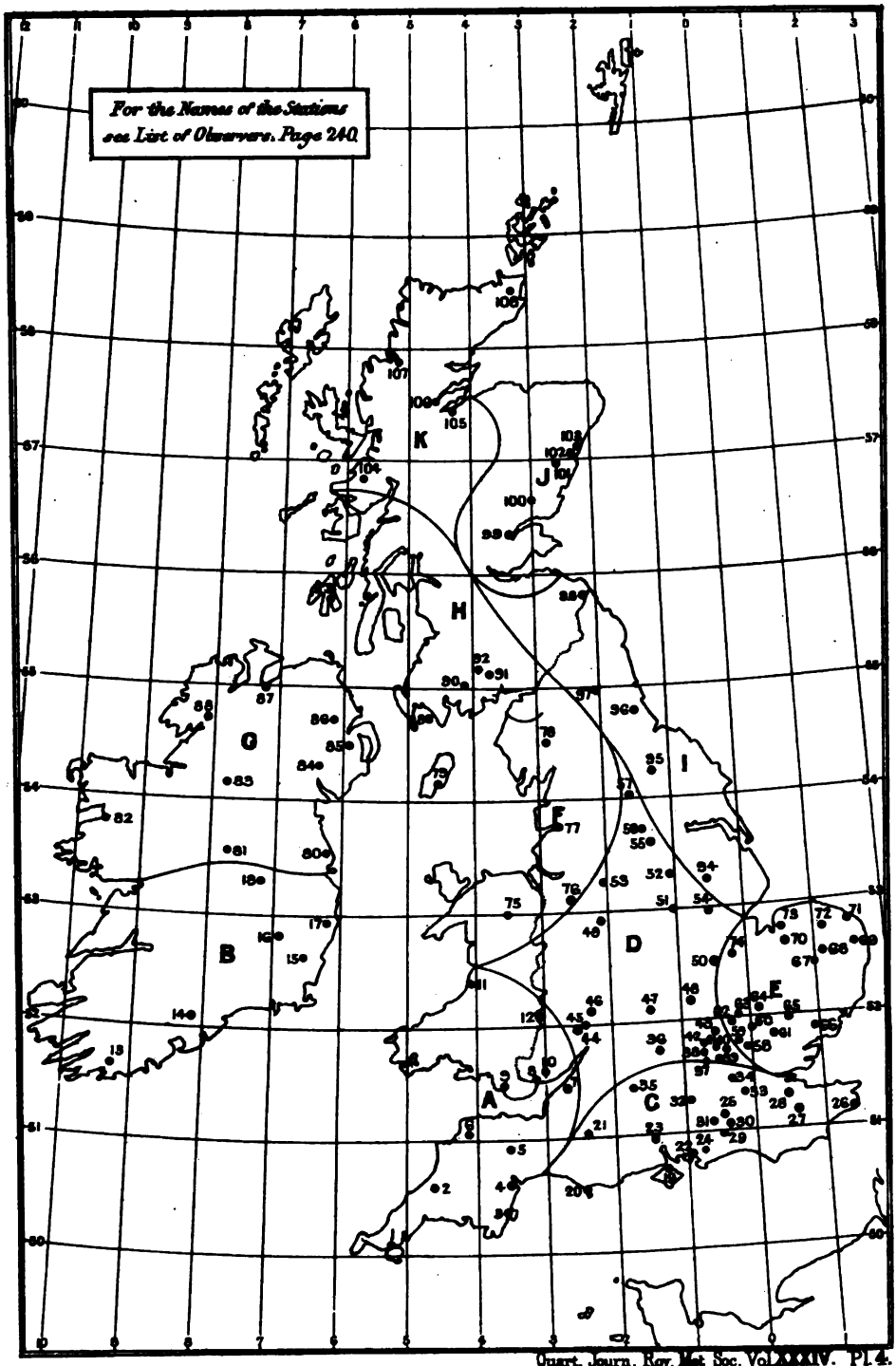
A fresh stimulus for observing came at the end of the fifteenth century from quite another direction. The great discoveries of new lands and seas considerably enlarged and widened old ideas and conceptions. Atmospheric phenomena never seen before came to the knowledge of man, and climates very different to those at home became known. Intelligent men were struck by such varieties, and we can clearly observe their effect on them in the writings of that epoch. Luis de Camões, the famous Portuguese poet, described in his epos, *Os Lusiadas*, for the first time minutely the water-spouts often observed by him off the coast of Guinea and the storms in the South Indian Ocean, while from the logbook kept by Christopher Columbus during his first voyage we learn the deep impression he got from the difference of climate and weather in the Atlantic beyond the Azores compared with that eastwards of the islands. Such new observations advanced mostly the doctrine of the winds, which was now more fully expounded in Spanish and Portuguese works, until in the year 1622 Francis Bacon was the first to publish a special treatise dealing entirely with the winds.

But meanwhile experimental science, the growing up of which I have just alluded to, was so much developed that in the first half of the seventeenth century the principal meteorological instruments were invented. To Italy belongs the glory of being the native country of instrumental meteorology, the cradle of which stood at Florence. These inventions proved the first step in making meteorology a science, and now the shadows of the dawn are fast disappearing before the full light of the rising sun.

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MAP SHOWING POSITION OF THE PHENOLOGICAL STATIONS, 1907.



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REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1907.

By EDWARD MAWLEY, F.R.Met.Soc., V.M.H.

(Plate 4.)

[Read April 15, 1908.]

THE following changes have taken place in the observing stations since the last Report was issued. No returns were received during the year from Sidcot and St. Arvans in District **A**; Churt and Bagshot in District **C**; Roxton in District **E**; Birkdale (Southport) and Lake Side in District **F**; and Blyth in District I. On the other hand, new stations have been started at Whitney-on-Wye in District **A**; Weymouth and Ditton Hill in District **C**; Dymock, King's Langley, Stone, and Kelton in District **D**; Ambleside in District **F**; and West Foulden in District I. The total number of observing stations is now 109.

TABLE I.—MEAN RESULTS, WITH THEIR VARIATIONS FROM THE 17 YEARS' AVERAGE (1891-1907), FOR THE THIRTEEN PLANTS IN THOSE DISTRICTS WHERE THERE HAVE BEEN SUFFICIENT OBSERVATIONS TO WARRANT COMPARISONS BEING MADE.

Years.	Eng. S.W.		Eng. S.		Eng. Mid.		Eng. E.		Eng. N.W.	
	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.
		Days.		Days.		Days.		Days.		Days.
1891	144	+ 9	144	+ 8	150	+11	147	+10	150	+ 6
1892	139	+ 4	138	+ 2	144	+ 5	143	+ 6	147	+ 3
1893	118	−17	122	−14	125	−14	123	−14	128	−16
1894	126	− 9	130	− 6	135	− 4	127	−10	137	− 7
1895	139	+ 4	138	+ 2	141	+ 2	138	+ 1	144	0
1896	125	−10	128	− 8	132	− 7	130	− 7	134	−10
1897	130	− 5	132	− 4	136	− 3	132	− 5	142	− 2
1898	133	− 2	135	− 1	138	− 1	136	− 1	141	− 3
1899	136	+ 1	136	0	141	+ 2	138	+ 1	145	+ 1
1900	142	+ 7	141	+ 5	144	+ 5	143	+ 6	152	+ 8
1901	138	+ 3	139	+ 3	141	+ 2	139	+ 2	144	0
1902	139	+ 4	140	+ 4	145	+ 6	142	+ 5	152	+ 8
1903	134	− 1	134	− 2	137	− 2	134	− 3	145	+ 1
1904	139	+ 4	139	+ 3	142	+ 3	140	+ 3	149	+ 5
1905	133	− 2	135	− 1	138	− 1	136	− 1	144	0
1906	135	0	134	− 2	138	− 1	137	0	143	− 1
1907	142	+ 7	139	+ 3	143	+ 4	142	+ 5	149	+ 5
Mean	135	...	136	...	139	...	137	...	144	...

Explanation of the Dates in the Tables.

1- 31	are in January.	182-212	are in July.
32- 59	,, February.	213-243	,, August.
60- 90	,, March.	244-273	,, September.
91-120	,, April.	274-304	,, October.
121-151	,, May.	305-334	,, November.
152-181	,, June.	335-365	,, December.

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The averages, with which the mean dates of the different plants are compared in Table IV., have been obtained from the actual observations made during the 17 years 1891-1907 in all those districts where sufficient observations were available. Those for the two remaining districts are as near approximations to the true averages as the limited number of records will allow.

The Winter of 1906-7.

This was everywhere a cold and dry season, with an unusually good record of sunshine. The temperature was very variable, but the colder periods as a rule lasted much longer than those which were unseasonably warm. In all three months the rainfall was below the average. It was a remarkably sunny winter, especially in the midland, north-western, and north-eastern counties of England, and in the east of Scotland.

The accounts received from different parts of the country vary considerably, but in most districts, notwithstanding the frequent interruptions from rain and frost, good progress appears on the whole to have been made with the cultivation of the land for spring corn. During the last week in November, and the early part of December, wheat sowing, which had been stopped by the previous long period of heavy rain, was resumed, and under more favourable conditions than at any time since September. The autumn-sown cereals came up slowly but well, and continued to present a promising appearance throughout the winter. During the severe frosts which occurred for a short time towards the end of December, they were fortunately protected by a deep covering of snow, and when the frost had gone out of the ground the surface soil was made firm again by the moderately heavy rainfall which followed. Good progress was also made with ploughing the land in Scotland and the north of England, but the hindrances through rain and frost were there more frequent and prolonged.

Until destroyed by the Christmas frost an unusual number of flowers were still to be seen here and there in sheltered places in the gardens, throughout the winter, in the southern half of England. In the middle of January there occurred a dry period which was particularly favourable for transplanting fruit-trees, shrubs, roses, etc., as the soil had been rendered friable through the recent frosts, and was at the same time warm and moist, without being too wet. The preparation of the soil for the reception of spring garden crops was carried on with comparatively few interruptions, considering the variable character of the season.

The fertile flowers on the hazel, taking the country as a whole, made their appearance 5 days later than usual.

The song-thrush was first heard after the beginning of January, 1 day in advance of its average date.

The honey-bee was first seen to visit flowers 3 days late.

The Spring.

March proved warm, dry, and sunny, whereas both April and May were cold, wet, and cloudy. The frequency of the rainfall in April and May was more exceptional than the quantity which fell at any one time.

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There was a splendid record of sunshine in March, and a very poor record in May, while in April the departures from the average duration were in most districts small.

During the dry periods in March a good deal of spring corn was sown with little labour, and in the most satisfactory manner. The next two months were moderately wet, but the ground so readily absorbed the rain which fell, that no sooner was the sowing of the spring cereals completed than the seeding of mangolds, swedes, and turnips was proceeded with, and for these crops a fine and moist tilth was readily obtained. The autumn-sown corn continued to make good growth, and at the end of the spring was as healthy and strong as could be wished, without being too forward. The pastures and meadows were unusually bare during the early part of the season, but before the end of May, favoured by the moderate temperatures and occasionally heavy rains, good progress had been made, while the undergrowth at that period was thicker than for many years past. In the colder parts of the British Isles the conditions for working the land and sowing spring corn and the root crops were almost as favourable as in the south.

As was the case on the farm, the seeds sown in the garden, as a rule, germinated slowly but regularly, scarcely any failing. There was a profusion of bloom on the lilacs, laburnums, and other flowering shrubs, while the flower clusters were exceptionally fine. The fruit-trees also were laden with blossom, but the continued cold and sunless weather prevented many of the flowers setting their fruit, and more particularly was this the case with the apple-trees, which happened to be in full bloom when the night frosts in May were most severe.

All the spring migrants on the list, except the garlic hedge mustard, which blossomed at its average date, flowered later than usual, the coltsfoot being 6 days late, the wood anemone, blackthorn and horse-chestnut 1 day late, and the hawthorn 5 days late.

Of the spring migrants included in the report, the swallow was 3 days late, the cuckoo 6 days late, the nightingale 4 days late, while the flycatcher made its appearance at its average date.

The wasp first appeared 1 day late, the small white butterfly 3 days early, and the orange-tip butterfly 5 days late.

The Summer.

Each of the summer months was cold, and in all but three districts the fall of rain was in excess of the average; but, as was the case in the previous season, it was rather the frequency of the rain than its exceptional heaviness at any one time which was a noteworthy feature of the season. The record of sunshine was deficient in each month, and more particularly in June.

Favoured by the frequent falls of rain in the early part of the season the crop of hay was a heavy one. Owing, however, to the continuance of the same wet, dull, and cold weather after the grass had been cut, it was in most cases gathered in in an indifferent condition. In fact, in the southern half of England the only really good hay appears to have been secured during a dry week in the middle of July. Notwithstanding the cold and sunless weather the corn crops continued to make

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satisfactory and healthy growth. The roots also improved, and there was always a good crop of herbage in the pastures. The great drawback in a summer of such frequent rainfall was the difficulty of keeping under the plague of weeds, which, owing to the wet state of the ground, have seldom been at this season so much beyond control. The

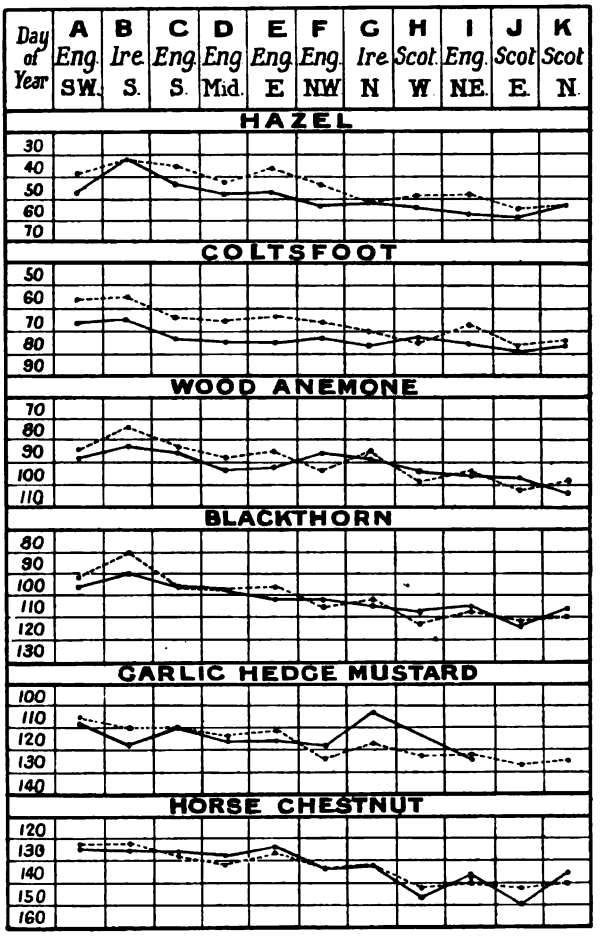


FIG. 1.

corn harvest was entered upon late, but in the most favourable weather possible, so that a good deal of corn had been harvested in excellent condition before the end of the summer. In the south of Scotland the interruptions to the hay harvest seem to have been less frequent than in others parts of the kingdom, so that a great part of the crop was gathered in under favourable circumstances. On the other hand, throughout the colder districts of these islands the sowing of turnips and swedes was

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greatly delayed by wet weather, indeed in some parts of Scotland it was not completed until the middle of July. In Scotland oats, however, made good growth, particularly during the warm week in the middle of July, and promised at the end of the season to yield a heavy crop, both of grain and straw.

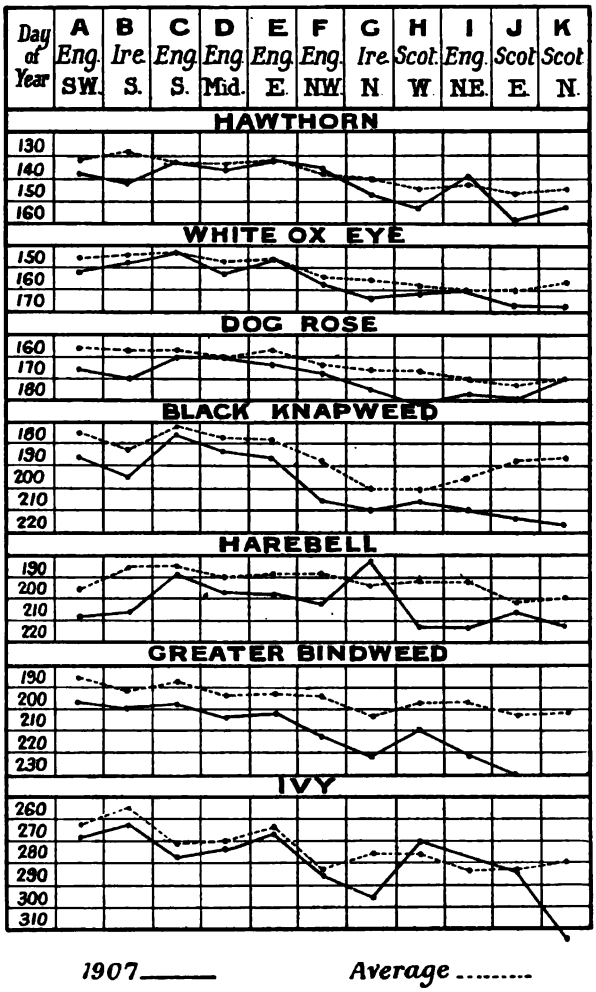


FIG. 2.

The cool weather and frequent rainfall which were such noteworthy features of the summer months suited the vegetables in the kitchen garden, and more particularly peas and beans, which made unusually good growth. The same conditions, however, were less favourable in the flower garden, the progress of many plants being kept in check by the cold state of the ground. Trees and shrubs, on the other hand, were greatly benefited by the continued moisture both above and below ground.

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Owing to the coolness of the season the hawthorn and other flowering shrubs and trees remained a much longer time than usual in blossom. There was a noticeable scarcity of butterflies.

All the summer flowering plants on the list came into blossom behind their usual dates, the white ox-eye being 4 days late, the dog-rose 7 days late, the black knapweed 13 days late, the harebell 10 days late, and the greater bindweed 14 days late.

The meadow brown butterfly made its appearance 16 days later than usual.

The Autumn.

This was in all parts of the kingdom a warm autumn. September and November proved dry, whereas in October the rainfall was unusually heavy. September was a very sunny month, but taking the two other months together the record of sunshine was on the whole under average.

The fears of the previous season as to the further progress of the harvest were soon dispelled, for September proved a perfect harvest month, indeed after the first few days scarcely a drop of rain fell. Seldom have farmers in the southern half of England had such a splendid time for getting in a heavy yield of corn in such excellent condition, there being no sprouting or discoloration of the grain, while the straw was bright and also unusually abundant. In many cases, however, a good deal of the corn had previously been beaten down by heavy rains and high winds, and consequently had to be cut by hand, which made the harvest more tedious and expensive than it otherwise would have been. Throughout the greater part of the kingdom the harvest had been completed by the end of the third week in September. The cool wet weather in October favoured the root crops, which before the end of the season had made excellent growth. Potatoes, however, were in most districts found to have become much diseased when lifted. The pastures continued green throughout the autumn, notwithstanding the long spell of dry weather in September. The preparation of the land for the reception of the autumn cereals was much delayed owing to the late harvest, and again by the sodden condition of the ground during the last fortnight in October and the same period in November. For the first time since the winter the farmer was enabled to clear the land of weeds, which had grown almost unchecked throughout the whole of the spring and summer.

In the colder parts of Scotland the weather proved very trying to the farmers, for scarcely had a long and tedious hay harvest come to an end than the corn harvest began under equally unfavourable conditions. The crop of oats was a large one, but remained so long in the fields that when at last gathered in the grain was found to be discoloured, while much of it had sprouted. Potatoes in Scotland were small, but only to a moderate extent diseased.

Seldom have gardens been as gay with flowers, considering the time of year, as they were during the early part of this autumn, and owing to the absence of early frosts the flowering period has not often been as long extended. Vegetables of all kinds made unusually good growth, with the single exception of tomatoes, for which the summer had been much too cold and sunless. The early part of November proved an exceptionally favourable time for transplanting fruit-trees, shrubs, etc., as

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the October rains had penetrated the ground to a sufficient depth to allow of the plants being taken up without injury to their roots, and replanted in their new quarters under the most favourable conditions. As was the case in the fields, there was a good deal of disease amongst the potatoes.

Trees held their foliage until an unusually late date, and the autumn tints were, as a rule, poor. There appears to have been an unusually small number of wasps and house-flies during this season.

The only autumn plant on the list, the ivy, came into flower 8 days later than its average date.

Taking the country as a whole, the last swallow took its departure 4 days later than its usual time.

According to the *Preliminary Statement* for Great Britain, issued by the Board of Agriculture, the yield of wheat per acre exceeded the average for the previous ten years by 2·74 bushels, barley by 2·12 bushels, beans by 5·00 bushels, and peas by 2·34 bushels. All these four crops were in each case with one exception heavier than in any year since official statistics were first collected, while that of oats was 3·75 bushels per acre above the ten years average, and heavier than in any year of the same period. Turnips and swedes exceeded the average by 0·98 ton, mangolds by 0·67 ton, hay (permanent pasture) by 3·24 cwts., and hay (clover, etc.) by 3·41 cwts. The only deficient crop was that of potatoes, which was 0·33 ton per acre below the average.

For the first time since Dr. Shaw directed attention to the close connection between the character of the autumn rainfall and the yield of wheat in the following year his conclusions failed to be confirmed by the result of the harvest. In the first place, in 1906, in five out of the eleven districts into which the country is divided, the autumn rainfall was in excess of the average, and then again the yield of wheat in 1907 was not only good, but the heaviest with one exception for many years.

The yield of fruit was variable, but on the whole poor. Apples, pears, and strawberries were decidedly under average both in size and quantity, but there was a good crop of plums, and a moderately good one of raspberries, currants, and gooseberries.

The Year.

The most noteworthy features of the weather of the phenological year ending November 1907, as affecting vegetation, were the cold and sunless character of April, May, and the three summer months, the frequent falls of rain during that period, the warm, dry, and sunny weather in September, and the heavy and continuous rainfall in October. Wild plants came into blossom behind their usual dates throughout the whole of the flowering season. Such early spring migrants as the swallow, cuckoo, and nightingale were also behind their average dates in reaching these Islands. The only deficient farm crop, taking the country as a whole, was that of potatoes, most of the other crops being much over average. On the other hand, the yield of apples and pears, and particularly the former, was below average. There was also a deficient crop of strawberries, whereas plums, raspberries, currants, and gooseberries were over average. As regards the farm crops it may be

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TABLE II.—List of the Stations with the Names of the Observers.

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
A			
1. Mawnan	Cornwall	200	Miss R. Barclay.
2. Altarnon	Cornwall	600	C. U. Tripp, M.A.
3. Brixham	Devon	40	F. W. Millett.
4. Starcross	Devon	50	P. G. Waterfield.
5. Tiverton	Devon	270	Miss M. E. Gill.
6. Barnstaple	Devon	90	T. Wainwright.
7. Clifton	Gloucester	300	G. C. Griffiths, F.E.S.
8. Penarth	Glamorgan	120	G. A. Birkenhead.
9. Bridgend	Glamorgan	90	H. J. Randall, Junr.
10. Little Mill	Monmouth	300	W. J. Grant, F.R.H.S.
11. Aberystwith	Cardigan	30	J. H. Salter, D.Sc.
12. Whitney-on-Wye.	Hereford	430	W. Burgess.
B			
13. Skibbereen	Cork	30	W. F. Wolfe.
14. Tallow	Waterford	...	Mrs. H. C. Deane.
15. Ferns	Wexford	260	G. E. J. Greene, M.A., D.Sc., F.L.S.
16. Bagenalstown	Carlow	290	Miss F. S. Wynne.
17. Ovoca	Wicklow	110	Miss W. F. Wynne.
18. Geashill	King's County	280	Rev. Canon Russell.
C			
19. Bembridge	Isle of Wight	80	C. Orchard, F.R.H.S.
20. Weymouth	Dorset	100	N. M. Richardson.
21. Buckhorn Weston	Dorset	290	Miss H. K. H. D'Aeth.
22. Havant	Hants	30	H. Beeston.
23. Botley	Hants	30	Lady Jenkyns.
24. Birdham	Sussex	10	A. J. Nixon.
25. Muntham	Sussex	250	P. S. Godman, F.Z.S.
26. Dover	Kent	150	F. D. Campbell.
27. Staplehurst	Kent	110	Rev. J. S. Chamberlain.
28. Maidstone	Kent	100	Mrs. Silcock.
29. Chiddingfold	Surrey	230	Admiral Maclear (the late).
30. Cranleigh	Surrey	180	Miss H. E. Ravenscroft.
31. Coneyhurst	Surrey	600	J. Russell.
32. Churt Vicarage	Surrey	350	Rev. A. W. Watson.
33. Purley	Surrey	350	J. E. Clark, F.R.Met.Soc.
34. Ditton Hill	Surrey	...	H. T. Potter.
35. Marlborough	Wilts	480	E. Meyrick, F.R.S.
D			
36. Oxford	Oxford	200	F. A. Bellamy, M.A., F.R.A.S.
37. Harefield	Middlesex	340	G. E. Eland.
38. Chesham	Bucks	300	Miss G. Keating.
39. Watford	Herts	270	Mrs. J. Hopkinson.
40. St. Albans (New Farm)	Herts	400	Miss A. Dickinson.
40. St. Albans (Glenferrie Road)	Herts	320	W. P. Westell, F.R.H.S., M.B.O.U.
41. King's Langley	Herts	400	M. Arnold.
42. Berkhamsted	Herts	400	Mrs. E. Mawley.
43. Harpenden	Herts	370	J. J. Willis.
44. Ross	Hereford	210	H. Southall, F.R.Met.Soc.
45. Dymock	Gloucester	120	Miss M. Peake.
46. West Malvern	Worcester	600	Mrs. Kensington.
47. Farnborough	Warwick	520	Miss D. J. G. Prater.
48. Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.

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TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
49. Stone	Stafford	330	W. Wells Bladen.
50. Ketton	Rutland	290	Rev. A. H. Snowden.
51. Beeston	Notts	210	G. Fellows.
52. Hodsock	Notts	60	Miss Mellish, F.R.H.S.
53. Macclesfield	Cheshire	500	J. Dale.
54. Belton	Lincoln	200	Miss F. H. Woolward.
55. Altofts	Yorks (W.R.)	120	H. G. Townsend.
56. Horbury	Yorks (W.R.)	210	W. Rushforth.
57. Ripley	Yorks (W.R.)	240	Rev. W. T. Travis.
E			
58. Broxbourne	Herts	120	Rev. H. P. Waller.
59. Hatfield	Herts	380	Miss R. Blackett.
60. Hertford	Herts	140	W. Graveson.
61. Sawbridgeworth	Herts	350	H. S. Rivers.
62. Hitchin	Herts	220	A. W. Dawson, M.A.
63. Odsey (Ashwell)	Cambridge	260	H. G. Fordham.
64. Shelford	Cambridge	60	C. E. Smith.
65. Bocking	Essex	240	H. S. Tabor, F.R.Met.Soc.
66. Lexden	Essex	90	S. F. Hurnard.
67. Carleton-Forehoe	Norfolk	100	Rev. C. H. Master.
68. Tacolneston	Norfolk	190	Miss E. J. Barrow.
69. Eaton (Norwich)	Norfolk	100	A. W. Preston, F.R.Met.Soc.
70. Southacre	Norfolk	100	Rev. E. T. Daubeney.
71. Brunstead	Norfolk	30	Rev. M. C. H. Bird.
72. Hevingham	Norfolk	...	Major Marsham.
73. Clenchwarton	Norfolk	10	Miss E. M. Stevenson.
74. Peterborough	Northampton	30	J. W. Bodger.
F			
75. Llangollen	Merioneth	270	T. Ruddy.
76. Betley	Stafford	250	Miss M. L. Hodgson.
77. Preston	Lancashire	50	J. R. Charnley, F.G.S., F.Z.S.
78. Ambleside	Westmoreland	220	Miss Drury.
79. Cronkbourne	Isle of Man	110	A. W. Moore and J. Murphy.
G			
80. Ardgillan	Dublin	210	J. Woodward.
81. Edgeworthstown	Longford	270	J. M. Wilson, M.A.
82. Westport	Mayo	10	J. M. McBride.
83. Chanter Hill	Fermanagh	250	The Dean of Clogher.
84. Loughbrickland	Down	350	Rev. Canon Lett.
85. Saintfield	Down	310	Rev. C. H. Waddell, M.A.
86. Antrim	Antrim	70	Rev. W. S. Smith.
87. Altnafoyle	Londonderry	450	T. Gibson.
88. Milford	Donegal	150	Miss Osborne.
H			
89. Kirkmaiden	Wigtown	100	Rev. D. R. Williamson.
90. New Galloway	Kirkcudbright	450	T. R. Bruce.
91. Jardington	Dumfries	100	J. Rutherford.
92. Moniaive	Dumfries	350	J. Corrie.
93. Port Ellen	Isle of Islay	10	T. F. Gilmour.
I			
94. Doddington	Lincoln	90	Rev. R. E. Cole.
95. Thirsk	Yorks (N.R.)	120	A. B. Hall.
96. Durham	Durham	350	Prof. R. A. Sampson and F. C. H. Carpenter.

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TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
97. Corbridge-on-Tyne	Northumberland	200	A. W. Price.
98. West Foulden .	Berwick . .	250	J. H. Craw.
J			
99. Forgandenny .	Perth . .	...	D. Nicoll.
100. Kirriemuir .	Forfar . .	250	T. M. Nicoll.
101. Durris . .	Kincardine .	420	A. Macdonald, M.A.
102. Crathes . .	Kincardine .	140	J. Smith, F.R.Met.Soc.
103. Aberdeen . .	Aberdeen .	40	P. Harper.
K			
104. Invermoidart .	Inverness . .	60	S. M. Macvicar.
105. Beauly . .	Inverness . .	60	A. Birnie.
106. Dingwall . .	Ross . .	10	J. P. Smith, M.D.
107. Inverbroom .	Ross . .	50	Lady Fowler.
108. Watten . .	Caithness . .	150	Rev. D. Lillie.

The numbers before the names of the stations refer to their position on the Map of the Stations. (Plate 4.)

stated that 1905 was a plentiful year, in 1906 the yield was even better, while the past year proved the most bountiful of the three.

Observers' Notes.

December 1906.—*Mawnan* (A)—1st. Broad beans have sent up a second growth from the roots which are now from two to three feet high and in full flower. *Altarnon* (A)—Wild geese, swans and other migrants usually numerous. *Penarth* (A)—1st. Geraniums and nasturtiums still flowering. 29th. Nasturtiums killed. *Whitney-on-Wye* (A)—21st. Cut some good roses. *Havant* (C)—Two sand-martins were seen in full vigour of flight on the 21st, but after that only one was seen, which remained until January 12, 1907. *Maidstone* (C)—30th. It has been so mild that many trees still hold their leaves. *Churt Vicarage* (C)—On Christmas Day chrysanthemums, violets, roses, and wallflowers were still in flower. *King's Langley* (D)—Gathered a good rose bloom on Christmas Day. *Ross* (D)—4th. Bat seen. *Hodsock* (D)—A great many berries on the holly. Two or three roses on the wall still in flower on Christmas Day. *Brunstead* (E)—9th. Trees struck by lightning during a snowstorm. *Birkdale (Southport)* (F)—18th. Holly berries not very plentiful. *Milford* (G)—16th. Bats flying.

January 1907—*Whitney-on-Wye* (A)—Brussel sprouts have suffered considerably from frost, and cabbages slightly. *Betley* (F)—31st. Some wild flowers still out in sheltered spots.

February—*Altarnon* (A)—12th. Wallflowers crippled by recent winds and frost. *Whitney-on-Wye* (A)—14th. The birds have cleared off all the holly berries. *Ovoca* (B)—24th. Frog spawn first seen. *Buckhorn Weston* (C)—Vegetation remarkably late owing to frosts in January and at times in February. *Botley* (C)—Many redwings and fieldfares. *Churt Vicarage* (C)—Fieldfares

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TABLE III.—Date (Day of Year) of First Flowering of Plants, 1907.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
A													
Mawnan . .	52	78	91	101	...	128	137	...	...	...	...	...	258
Altarnon . .	*72*	79	108	109	127	134	155	167	171	206	212	*237*	255
Brixham . .	58	77	...	81	...	119	133	...	173	...	...	201	274
Starcross . .	...	52	...	83	112	116	*115*	149	155	164	...	180	263
Tiverton . .	47	65	88	92	106	126	146	...	...	...	...	...	277
Barnstaple . .	18	57	90	97	98	120	136	159	169	194	212	196	271
Clifton . .	...	...	...	102	...	121	132	...	...	...	...	...	...
Bridgend . .	*62*	71	86	111	121	135	142	161	171	185	208	...	270
Little Mill . .	47	58	81	84	99	105	126	138	159	173	...	178	*245*
Aberystwith .	49	57	89	92	102	128	129	138	164	188	203	204	263
Whitney-on-Wye .	52	....	83	105	...	...	134	146	168	195	210	222	292
B													
Skibbereen . .	29	...	69	90	...	...	...	...	...	...	...	...	...
Tallow . .	...	*3*	...	83	...	105	*111*	...	164	201	...	200	267
Ferns . . .	*61*	80	98	91	...	*96*	135	149	170	206	231	*231*	257
Bagenalstown .	...	78	...	95	...	131	143	...	...	207	...	...	...
Ovoca . . .	21	47	81	80	...	131	138	145	...	204	...	...	...
Geashill . .	42	56	80	96	119	133	148	151	176	161	180	...	...
C													
Bembridge . .	*62*	60	...	99	118	117	126	133	160	164	...	...	...
Weymouth . .	...	...	89	93	...	129	...	...	174	...	...	209	272
Buckhorn Weston	47	72	82	100	101	131	132	141	161	172	...	199	269
Havant . .	18	79	...	95	98	134	...	143	146	166	...	200	275
Botley . .	50	79	77	103	125	131	133	147	174	*196*	...	...	288
Birdham . .	48	...	...	67	112	119	131	138	161	185	...	...	...
Muntham . .	47	76	85	98	103	129	131	143	152	176	...	188	285
Dover . . .	...	*91*	...	91	...	127	141	...	166	193	...	...	280
Staplehurst . .	51	76	81	94	100	115	126	133	147	167	183	185	...
Maidstone . .	55	63	88	103	106	126	130	135	151	168	...	201	257
Chiddingfold .	49	76	86	95	109	120	135	138	...	...	...	...	...
Cranleigh . .	46	...	85	89	112	125	134	141	156	*209*	...	193	283
Coneyhurst . .	57	87	86	99	...	129	134	149	164	194	189	192	277
Churt Vicarage .	32	...	...	103	112	126	132	147	161	179	182	214	...
Purley . .	61	61	89	102	122	125	133	146	161	...	...	...	...
Ditton Hill . .	...	81	...	106	111	125	131	146	162	179	...	213	285
Marlborough .	15	73	83	93	109	129	134	153	160	166	203	183	...
D													
Oxford . .	...	75	90	93	96	121	137	146	152	...	...	...	268
Harefield . .	62	88	90	103	...	127	131	...	153	198	210	206	...
Chesham . .	56	78	94	102	124	133	137	*162*	166	165	...	199	267
Watford . .	46	76	...	95	104	125	130	146	162	...	193	...	275
St. Albans (New Farm)	22	78	90	94	114	...	130	151	153	200	185	...	272
St. Albans (Glenferrie Road)	20	88	89	90	108	132	140	153	159	171	...	215	286
King's Langley .	61	...	...	98	...	132	134	152	167	...	...	...	...
Berkhamsted .	57	79	104	104	114	130	141	146	158	197	208	201	267

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TABLE III.—Date (Day of Year) of First Flowering of Plants, 1907—*continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
Harpenden	53	75	103	102	114	130	137	149	163	171	...	...	...
Ross	47	61	89	*84*	106	115	127	...	153	...	...	...	...
Dymock	...	77	87	105	106	...	134	...	159	167	...	...	275
West Malvern	58	68	*58*	102	99	128	132	158	161	171	191	202	*227*
Farnborough	17	63	94	92	114	137	135	146	161	187	...	213	273
Northampton	60	80	84	94	122	129	131	148	160	177	181	211	264
Stone	...	...	...	...	...	141	140	...	...	...	...	...	...
Ketton	...	...	...	...	...	...	...	...	160	...	...	...	264
Beeston	...	79	...	108	130	128	132	156	...	194	*157*	...	...
Hodsock	52	76	90	97	115	119	131	162	172	202	200	192	274
Macclesfield	60	88	119	114	137	144	145	165	173	189	190	197	276
Belton	39	61	82	93	129	131	133	154	154	191	201	208	276
Altofts	62	...	89	...	117	124	124	...	...	...	...	...	...
Horbury	...	71	84	...	118	124	134	*190*	...	...	217	...	...
Ripley	...	59	...	...	125	133	149	...	...	...	...	...	...
E													
Broxbourne	46	71	96	...	114	...	...	...	161	...	...	...	263
Hatfield	56	...	92	...	...	...	129	145	153	...	209	...	...
Hertford	34	69	83	83	97	129	132	142	167	181	204	*180*	265
Sawbridgeworth	49	75	...	107	...	...	...	...	168	...	...	...	...
Hitchin	...	...	...	...	...	127	130	...	155	...	...	...	...
Odsey (Ashwell)	18	83	...	...	...	...	130	...	158	...	...	...	274
Shelford	35	...	...	113	...	127	130	132	*135*	...	*166*	...	...
Bocking	47	81	89	100	121	118	130	144	154	210	209	218	273
Lexden	61	87	105	106	121	125	130	137	157	179	197	190	271
Carleton-Forehoe	45	82	100	106	111	129	133	153	167	182	206	...	270
Tacolneston	53	76	90	...	...	109	131	152	164	172	...	203	...
Eaton (Norwich)	58	...	...	...	125	127	132	149	168	...	...	211	...
Southacre	...	61	83	92	104	128	132	152	167	169	173	197	258
Brunstead	56	...	...	110	112	132	134	155	167	210	204	213	...
Hevingham	...	...	85	...	...	...	128	...	...	...	...	...	...
Clenchwarton	...	65	...	...	130	127	131	...	162	*226*	...	191	257
Peterborough	49	71	86	91	111	119	131	143	162	187	191	197	283
F													
Langollen	50	56	87	91	110	126	131	145	163	205	201	208	284
Betley	46	77	85	105	107	137	137	165	167	206	208	217	300
Preston	...	84	...	...	...	...	...	...	...	...	...	...	...
Ambleside	57	...	...	106	127	133	145	164	173	207	200	...	277
Cronkbourne	58	...	*116*	...	133	131	137	156	...	...	...	*238*	281
G													
Ardgillan	56	71	86	104	...	123	148	159	173	*226*	...	229	306
Edgeworthstown	...	...	87	112	...	139	147	...	169	...	...	...	...
Westport	36	...	*57*	105	...	111	145	...	165	...	...	...	...
Chanter Hill	46	61	88	89	104	134	144	162	177	200	182	229	285
Loughbrickland	54	81	105	116	...	140	145	...	176	...	...	229	...
Saintfield	60	80	91	105	...	137	152	167	177	...	...	...	...
Antrim	66	...	83	...	104	...	143	164	181	210	...	199	...

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TABLE III.—Date (Day of Year) of First Flowering of Plants, 1907—*continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
Altnafoyle . .	61	79	...	113	...	134	149	...	175	220	...	...	...
Milford . .	31	82	85	89	...	129	148	163	184	...	...	*266*	295
H													
Kirkmaiden. .	55	46	94	117	...	146	150	168	171	...	211	199	270
New Galloway .	46	82	98	*125*	...	153	163	*175*	184	*222*	209	...	...
Jardington . .	59	88	89	113	...	142	151	157	181	210	203	...	...
Moniaive . .	*70*	...	92	116	...	146	158	161	188	203	...	221	...
Port Ellen . .	54	...	...	92	...	...	144	...	...	...	...	...	...
I													
Doddington. .	64	84	97	101	127	127	133	...	163	...	...	...	...
Thirsk . .	49	58	88	104	118	133	135	158	177	203	210	221	...
Durham . .	57	79	99	110	...	...	...	...	...	...	...	...	...
Corbridge-on-Tyne	...	81	...	109	*135*	151	148	...	...	...	...	...	...
West Foulden .	...	...	...	...	...	...	...	162	191	216	214	...	...
J													
Forgandenny .	...	78	*138*	...	...	161	161	...	...	...	...	...	...
Kirriemuir . .	...	...	...	113	...	...	157	173	172	215	199	...	...
Durris. . .	59	79	88	114	...	134	...	168	175	208	212	230	283
Crathes . .	...	...	93	116	...	...	...	159	177	...	...	...	*343*
Aberdeen . .	...	80	109	...	...	155	159	...	196	...	*232*	...	...
K													
Invermoidart .	...	...	111	...	...	...	152	169	174	...	...	...	...
Beauly . .	51	...	114	118	...	144	151	170	171	201	215	...	314
Dingwall . .	56	73	88	103	...	131	147	167	173	...	209	...	...
Inverbroom. .	*25*	79	...	104	...	133	...	...	161	...	...	...	...
Watten . .	...	76	...	...	...	...	165	*200*	...	232	...	...	...

The dates in *italics* have not been taken into consideration when calculating the means given in Table IV.

more numerous than for many years past. *Harefield* (D)—27th. Bat first seen. *Berkhamsted* (D)—11th. Winter aconite in flower—23 days later than its average date for the previous 20 years, and later than in any year since 1891. *Odsey* (E)—28th. Rooks began to build. *Llangollen* (F)—Wallflowers much injured by frost. *Thirsk* (I)—25th. Rooks building.

March.—*Mawnan* (A)—1st. Veronicas, geraniums, and calceolarias in some part of garden killed by the January and February frosts. *Altarnon* (A)—At the end of the month on light soils pastures were becoming bare. *Aberystwith* (A)—26th. Small bats first seen. *Whitney-on-Wye* (A)—16th. Frog spawn first seen. *Ovoca* (B)—Autumn-sown peas destroyed by frost. *Berkhamsted* (D)—22nd. An early Rivers' peach on a south wall in blossom 1 day earlier than its average date in the previous 21 years. *Harpenden* (D)—8th. Rooks building. *Ripley* (D)—30th. Willow warbler first heard. *Cronkbourne* (F)—25th. Oat-sowing commenced. *Thirsk* (I)—20th. Frog spawn first seen.

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TABLE IV.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF 13 PLANTS IN 1907, AND THEIR VARIATIONS FROM THE 17 YEARS' AVERAGE, 1891-1907.

PLANTS.	A England, S.W.			B Ireland, S.			C England, S.			D England, Mid.		
	1907.	Average for 17 Years.	Variation from Average.	1907.	Average for 17 Years.	Variation from Average.	1907.	Average for 17 Years.	Variation from Average.	1907.	Average for 17 Years.	Variation from Average.
Hazel	46	39	+ 7	31	31	0	44	35	+ 9	48	42	+ 6
Coltsfoot	66	56	+ 10	65	55	+ 10	74	63	+ 11	75	65	+ 10
Wood Anemone	89	85	+ 4	82	74	+ 8	85	83	+ 2	92	89	+ 3
Blackthorn	96	91	+ 5	90	80	+ 10	96	96	0	99	99	0
Garlic Hedge-Mustard	109	107	+ 2	119	110	+ 9	110	110	0	115	114	+ 1
Horse-Chestnut	123	121	+ 2	125	121	+ 4	126	127	− 1	129	131	− 2
Hawthorn	137	131	+ 6	141	129	+ 12	132	132	0	135	134	+ 1
White Ox-Eye	151	146	+ 5	148	143	+ 5	142	142	0	152	149	+ 3
Dog Rose	166	156	+ 10	170	158	+ 12	160	158	+ 2	160	160	0
Black Knapweed	186	175	+ 11	196	182	+ 14	176	172	+ 4	184	178	+ 6
Harebell	209	195	+ 14	206	*186*	+ 20	189	185	+ 4	198	190	+ 8
Greater Bindweed	197	186	+ 11	200	191	+ 9	198	189	+ 9	203	192	+ 11
Ivy	269	264	+ 5	262	255	+ 7	277	271	+ 6	272	270	+ 2
Mean for the 13 Plants	142	135	+ 7	141	132	+ 9	139	136	+ 3	143	139	+ 4

PLANTS.	E England, E.			F England, N.W.			G Ireland, N.			H Scotland, W.		
Hazel	47	36	+ 11	53	44	+ 9	51	51	0	53	49	+ 4
Coltsfoot	75	63	+ 12	72	66	+ 6	76	70	+ 6	72	74	− 2
Wood Anemone	91	87	+ 4	86	93	− 7	89	86	+ 3	93	99	− 6
Blackthorn	101	98	+ 3	101	104	− 3	104	101	+ 3	109	112	− 3
Garlic Hedge-Mustard	115	111	+ 4	119	124	− 5	104	*119*	− 15	...	*122*	...
Horse-Chestnut	125	126	− 1	132	132	0	131	131	0	147	142	+ 5
Hawthorn	131	131	0	137	138	− 1	147	140	+ 7	153	144	+ 9
White Ox-Eye	146	146	0	157	153	+ 4	163	156	+ 7	162	159	+ 3
Dog Rose	162	157	+ 5	168	162	+ 6	175	166	+ 9	181	166	+ 15
Black Knapweed	186	179	+ 7	206	189	+ 17	210	200	+ 10	207	200	+ 7
Harebell	199	189	+ 10	203	189	+ 14	182	*194*	− 12	212	191	+ 21
Greater Bindweed	202	192	+ 10	212	194	+ 18	221	203	+ 18	210	*198*	+ 12
Ivy	268	265	+ 3	285	282	+ 3	295	277	+ 18	270	*277*	− 7
Mean for the 13 Plants	142	137	+ 5	149	144	+ 5	150	146	+ 4	156*	151*	+ 5*

PLANTS.	I England, N.E.			J Scotland, E.			K Scotland, N.			British Isles.		
Hazel	57	49	+ 8	59	*55*	+ 4	53	*53*	0	49	44	+ 5
Coltsfoot	75	68	+ 7	79	*77*	+ 2	76	*75*	+ 1	73	67	+ 6
Wood Anemone	95	94	+ 1	97	*101*	− 4	104	*99*	+ 5	91	90	+ 1
Blackthorn	106	108	− 2	114	*112*	+ 2	108	*110*	− 2	102	101	+ 1
Garlic Hedge-Mustard	122	121	+ 1	..	*127*	...	...	*125*	...	114	114	0
Horse-Chestnut	137	140	− 3	150	*142*	+ 8	136	*140*	− 4	133	132	+ 1
Hawthorn	139	142	− 3	159	*146*	+ 13	154	*144*	+ 10	142	137	+ 5
White Ox-Eye	160	160	0	167	*160*	+ 7	169	*158*	+ 11	156	152	+ 4
Dog Rose	177	170	+ 7	180	*172*	+ 8	170	*170*	0	170	163	+ 7
Black Knapweed	210	196	+ 14	212	*189*	+ 23	216	*187*	+ 29	199	186	+ 13
Harebell	212	191	+ 21	205	*202*	+ 3	212	*200*	+ 12	202	192	+ 10
Greater Bindweed	221	198	+ 23	230	*203*	+ 27	...	*201*	...	209	195	+ 14
Ivy	...	282	...	283	*282*	+ 1	314	*280*	+ 34	280	272	+ 8
Mean for the 13 Plants	143*	136*	+ 7*	161*	*153**	+ 8*	156†	*147†*	+ 9†	148	142	+ 6

* For 12 Plants. † For 11 Plants.

\+ indicates the number of days later than the average date.
− ,, ,, ,, earlier ,, ,,
o ,, average date (1891-1907).
The dates in *italics* are approximate averages.

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APRIL.—*Mawnan* (A)—1st. All our large marguerites are now dead. *Altarnon* (A)—Apples, pears, etc., showing luxuriant blossom. *Whitney-on-Wye* (A)—Growth in gardens very slow. *Bembridge* (C)—Plums and pears full of blossom. *Chiddingfold* (C)—26th. Blackthorn, wild cherry, and pear in remarkably profuse bloom. 30th. Grass in pastures short for the time of year. *Coneyhurst* (C)—26th. Sand-martin first seen. *Churt Vicarage* (C)—1st. Wryneck first heard. 10th. White-throat first seen. *Berkhamsted* (D)—14th. A wild cherry in my garden came into flower 5 days in advance of its average date in the previous 21 years. *Harefield* (D)—17th. Wryneck first heard. *Macclesfield* (D)—18th. Blossom on early plums destroyed by frost. *Ripley* (D)—11th. Sand-martin first seen. *Llangollen* (F)—Abundant blossom on wild cherry trees. *Corbridge-on-Tyne* (I)—Cuckoos not so numerous as usual, and it was longer before they changed their note. 28th. House-martin seen. 29th. Sand-martin seen. *Durris* (J)—13th. Sand-martin first seen. 22nd. House-martin first seen.

MAY.—*Altarnon* (A)—22nd. The frosts of the last few nights have killed rhododendron blossom and all the young shoots of the ivy, nettle, etc. *Whitney-on-Wye* (A)—22nd. Potatoes and runner beans blackened by frost. *Ovoca* (B)—In the third week potatoes blackened by sharp frosts. Hawthorn blossom abundant. *Weymouth* (C)—27th. The oaks have been in full leaf for some time, but the ashes only show the least sign of leaves at the tips of the branches. *Botley* (C)—Oaks quite free from caterpillars. Hardly any nightingales. 16th. Flowering shrubs exceptionally full of blossom. *Churt Vicarage* (C)—21st. The night frosts have done much damage to all fruit blossom. Gooseberries dropping off the bushes in the lower part of the parish. 21st. May-fly first seen. *Purley* (C)—18th. Walnut-trees in the Brighton valley below my house blackened by frost. *Oxford* (D)—24th. Chestnut blossoms beginning to fall. Owing to the cool weather they have lasted over three weeks. *Berkhamsted* (D)—4th. A Blenheim orange apple in my garden came into blossom 2 days earlier than its average date in the previous 21 years. *Dymock* (D)—An unusual number of queen wasps. 21st. Potatoes blackened by frost. *Macclesfield* (D)—24th. Ash-trees as yet quite leafless. *Tacolneston* (E)—Abundant blossom on the hawthorns. 10th. House-martin first seen. *Southacre* (E)—30th. Owing to the absence of sun the continued rain has begun to damage the crops. *Clenchwarton* (E)—30th. Blossom on hawthorn unusually abundant. *Llangollen* (F)—24th. Potatoes much injured by frost on the south side of the town, but only slightly injured on north side. *Durris* (J)—Fruit-trees flowering profusely.

JUNE.—*Altarnon* (A)—13th. Rapid growth of weeds. *Whitney-on-Wye* (A)—3rd. After the gale the ground was strewn with leaves as in winter. *Churt Vicarage* (C)—5th. Queen wasps very numerous this year. 11th. All flowering trees such as horse chestnut, laburnum, and hawthorn unusually beautiful this year. *Oxford* (D)—26th. Scarcely any grass has been cut. *Harpenden* (D)—17th. First wheat-ear out of sheath, or 4 days later than the average date for the previous 15 years. *Harefield* (D)—8th. Hay first cut. *Southacre* (E)—30th. Hawthorn still in bloom. *Clenchwarton* (E)—29th. A great many slugs and snails. *Llangollen* (F)—Vegetation almost at a standstill. *Betley* (F)—23rd. Hay cut because it was rotting near the ground. *Westport* (G)—1st. Hawthorn blossom completely ruined by hail. *Moniaive* (H)—Vegetation at the end of month at a standstill.

JULY.—*Whitney-on-Wye* (A)—Some good hay harvested between 14th and 20th. *Botley* (C)—An unusual number of swifts. Most butterflies and moths scarce. *Bembridge* (C)—7th. Sufficient snow fell for boys to make snowballs—a "record" for July. *West Malvern* (D)—5th. A hawthorn on the Malvern Hills now in full flower. *Farnborough* (D)—15th. Cuckoo last heard—ten days

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TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1907.

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A											
Mawnan	7	104	105	...	127	279	62	...	88	133	195
Altarnon	7	104	102	...	130	286	47	114	87	117	159
Brixham	13	113	126	...	...	292	...	...	108	...	193
Starcross	...	100	115	...	*154*	284	65	84	91	124	159
Tiverton	...	...	...	...	...	...	61	...	...	...	...
Clifton	...	106	...	...	...	...	...	*21*	63	...	...
Penarth	...	...	...	...	...	...	81	104	91	132	202
Bridgend	6	110	126	...	...	285	72	128	*133*	...	180
Little Mill	14	108	113	125	130	282	15	76	78	*96*	*124*
Aberystwith	8	104	125	...	131	*268*	...	80	88	117	180
Whitney-on-Wye	...	91	115	...	...	...	56	91	120	128	181
B											
Skibbereen	15	101	...	...	...	...	*3*	...	104	...	...
Tallow	...	99	...	...	...	...	79	...	...	...	...
Ferns	5	105	124	...	...	304	65	110	113	114	*114*
Bagenalstown	16	104	115	...	*110*	281	47	105	94	115	...
Ovoca	*38*	112	125	...	...	276	56	86	106	114	131
Geashill	...	102	127	...	...	290	53	*155*	116	130	...
C											
Bembridge	9	90	110	105	...	307	62	62	86	147	...
Weymouth	...	113	115	...	137	303	60	*10*	81	158	181
Buckhorn Weston	5	106	106	...	133	289	62	...	83	*104*	172
Havant	9	92	104	107	144	321	...	...	80	127	179
Botley	9	103	104	126	137	292	42	63	93	134	194
Birdham	9	88	103	112	...	331	18	...	...	119	...
Muntham	15	103	105	113	*162*	287	*11*	*142*	*139*	130	...
Dover	...	110	...	...	...	313	...	...	...	...	...
Staplehurst	...	104	104	104	147	...	17	...	86	128	...
Maidstone	*44*	114	103	115	...	...	76	114	89	...	...
Chiddingfold	10	103	92	112	131	...	58	94	90	131	149
Cranleigh	14	110	102	101	...	298	58	91	110	...	...
Coneyhurst	59	114	99	101	121	...	79	...	136	...	...
Churt Vicarage	8	105	113	114	133	281	58	107	92	126	170
Purley	7	114	112	112	...	285	61	114	88	...	...
Ditton Hill	8	*121*	113	113	...	291	...	...	94	...	...
Marlborough	*42*	100	114	112	133	...	...	...	100	133	170
D											
Oxford	...	*126*	105	...	...	...	...	...	126	...	...
Harefield	...	104	108	115	...	285	83	102	118	132	160
Chesham	...	101	106	131	...	274	58	92	...	132	...
Watford	...	113	110	117	...	295	58	105	105	...	...
St. Albans (New Farm)	6	106	113	108	133	295	63	93	107	131	193
St. Albans (Glenferrie Road)	6	125	124	124	138	...	58	91	*63*	132	...
King's Langley	...	*132*	125	116	...	...	...	124	126	...	...
Berkhamsted	14	102	106	114	*157*	293	58	91	89	131	164
Harpenden	...	123	109	121	...	...	78	61	108	...	...
Ross	4	110	124	113	*155*	...	48	...	112	...	...
Dymock	26	96	113	128	146	*238*	58	80	114	*105*	...
West Malvern	4	118	*90*	...	...	283	*6*	73	125	127	166

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TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1907—*continued.*

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange-Tip Butterfly.	Meadow Brown Butterfly.
Farnborough	1	108	115	127	135	282	17	72	87	152	195
Stone	10	100	115	...	122	307	...	...	...	133	...
Ketton	...	...	*145*	114	...	...	...	...	114	145	...
Beeston	9	96	118	...	...	266	80	90	90	...	...
Hodsock	42	115	125	123	133	305	15	89	96	161	...
Macclesfield	43	132	131	...	...	277	89	91	90	...	...
Belton	6	...	115	115	117	288	40	*204*	146	150	184
Altofts	47	97	...	...	...	...	...	...	...	...	...
Ripley	47	105	*89*	...	136	272	48	...	85	144	...
E											
Broxbourne	4	...	...	*96*	...	320	...	*51*	...	...	...
Hatfield	13	126	112	113	...	...	77	105	114	...	...
Sawbridgeworth	9	103	118	116	131	...	56	80	89	131	...
Hitchin	12	112	114	112	...	...	...	...	...	...	...
Odsey (Ashwell)	...	105	124	116	...	294	...	...	...	...	...
Shelford	...	95	114	118	...	303	...	117	119	133	143
Lexden	8	112	119	109	130	284	59	91	88	126	193
Carleton-Forehoe	18	105	115	121	132	...	52	83	84	128	...
Tacolneston	15	112	116	...	...	...	59	...	...	128	...
Eaton (Norwich)	...	...	125	...	...	...	...	...	...	...	...
Southacre	16	110	125	114	129	291	58	124	134	...	175
Brunstead	13	106	112	...	137	285	56	112	106	147	*209*
Hevingham	*46*	113	120	...	...	...	...	...	...	...	...
Clenchwarton	16	104	125	...	...	...	*8*	...	122	159	...
Peterborough	5	112	112	110	125	331	46	95	93	145	...
F											
Llangollen	40	106	112	...	132	279	84	95	86	132	...
Betley	49	104	113	...	138	291	87	90	113	*171*	201
Preston	8	125	125	...	...	306	15	103	91	...	...
Ambleside	47	113	116	...	129	...	...	...	126	144	205
Cronkbourne	53	123	131	...	...	*259*	39	126	106	148	153
G											
Ardgillan	14	111	114	...	136	269	59	112	106	134	183
Edgeworthstown	...	112	123	...	145	277	...	135	106	126	...
Westport	2	120	125	...	...	...	...	...	...	...	...
Chanter Hill	33	95	127	...	...	272	81	133	117	145	150
Loughbrickland	46	105	116	...	...	277	81	...	113	138	...
Saintfield	15	111	116	...	134	...	82	...	115	135	...
Antrim	15	115	125	...	145	275	73	111	98	126	...
Altnafoyle	49	*128*	130	...	...	...	*134*	145	128	137	199
Milford	14	119	125	...	...	266	77	134	131	139	...
H											
Kirkmaiden	25	104	130	...	...	285	83	124	...	136	...
New Galloway	54	126	126	...	...	...	56	126	...	...	...
Jardington	47	116	125	...	...	274	...	134	116	...	207
Moniaive	...	120	119	...	...	276	...	132	125	...	...
Port Ellen	21	119	128	...	...	...	*21*	...	124	139	...

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TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1907—*continued.*

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
I											
Thirsk	45	116	125	...	133	275	56	114	86	...	...
Durham	57	121	...	...	...	...	69	127	121	...	...
Corbridge-on-Tyne	49	119	127	...	...	271	...	...	...	...	...
West Foulden	...	...	...	...	...	284	...	...	...	...	197
J											
Forgandenny	48	131	132	...	147	...	58	87	149	...	...
Kirriemuir	...	128	136	...	...	274	56	*153*	...	...	...
Durris	20	115	124	...	145	279	56	90	112	169	190
Crathes	17	125	125	...	...	279	...	...	...	*221*	...
Aberdeen	42	128	*166*	...	...	*248*	91	86	...	...	...
K											
Invermoidart	50	...	126	...	...	...	...	101	...	...	...
Beauly	50	133	132	...	161	...	48	146	*201*	...	...
Dingwall	46	126	131	...	152	...	63	132	131	...	...
Inverbroom	57	...	128	...	...	...	61	146	139	...	...
Watten	...	...	*166*	...	...	...	59	...	133	...	203
Mean Dates for the British Isles in 1907	22 Jan. 22	110 Apl. 20	118 Apl. 28	115 Apl. 25	135 May 15	288 Oct. 15	59 Feb. 28	103 Apl. 13	105 Apl. 15	135 May 15	179 June 28
Mean Dates for 1891-1907	Jan. 23	Apl. 17	Apl. 22	Apl. 21	May 15	Oct. 11	Feb. 25	Apl. 12	Apl. 18	May 10	June 12

The dates in *italics* have not been taken into consideration when calculating the means for the British Isles.

later than I had ever heard it in the last 34 years. *Beeston* (D)—5th. Cuckoo still heard with unbroken note. 15th. Strawberries small and lacking flavour. *Hodsock* (D)—Many strawberries rotted on the ground instead of ripening. *Lexden* (E)—10th. Hail-storm sadly damaged many vegetables and flowering plants in the garden. *Southacre* (E)—15th. Heard the cuckoo's cry and even its gurgling note. *Clenchwarton* (E)—Wild rose blossoms still very abundant. *Betley* (F)—25th. Sweet peas remarkably good. *Thirsk* (I)—15th. Hay first cut. *Durris* (I)—8th. Cuckoo last heard.

August. *Altarnon* (A)—2nd. Hay still being harvested. *Mawnan* (A)—16th. Corn harvest began. *Brixham* (A)—Have not seen an orange tip butterfly this summer. *Whitney-on-Wye* (A)—9th. Corn harvest began, while some hay was still out in the fields. *St. Albans (New Farm)* (D)—7th. Dog-roses only now out of flower. Wasps and house-flies not so numerous as usual. *St. Albans (Glenferrie Road)* (D)—Marked scarcity of butterflies. *King's Langley*

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TABLE VI.—Estimated Yield of Farm Crops in 1907.

Description of Crop.	England.						Scotland.			Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H W.	J E.	K N.	B and G S. and N.	
	%	%	%	%	%	%	%	%	%	%	%
Wheat	+ 4	+ 8	+ 8	+11	+ 3	+ 6	- 3	0	+23	+ 3	+ 7
Barley	- 1	+ 5	+10	+ 9	- 5	+ 2	- 4	- 3	0	0	+ 6
Oats	+ 7	+13	+17	+12	+ 6	+ 8	- 5	+ 2	+ 1	0	+ 6
Corn Harvest began, average Date, day of Year	232	226	234	229	241	241	...	...	...	...	234
Beans	0	+16	+15	+17	+10	+ 6	+ 3	+ 1	-19	+10	+14
Peas	0	+12	+ 5	+10	+ 2	- 5	- 8	+ 2	+20	+ 8	+ 8
Potatoes	-29	- 7	- 4	+ 6	-27	-12	-13	- 9	-17	- 8	- 7
Turnips	+ 3	+19	+15	+11	- 1	+ 3	-29	- 6	+19	- 5	+ 5
Mangolds	+ 5	+ 7	+ 3	+10	- 1	0	-28	- 6	+15	+ 2	+ 3
Hay (Permanent Pastures)	+ 8	+14	+15	+ 7	+10	+11	- 2	+ 9	+18	0	+ 6
Hay (Clover, etc.)	+ 5	+17	+15	+ 9	+12	+15	+ 2	+ 9	+12	-17	+ 7

Symbols:—+ = Over. - = Under. 0 = Average.

The variations from the average in the above-mentioned crops have been obtained from the *Agricultural Returns*, 1907 (*Produce of Crops*), issued by the Board of Agriculture, while the average dates of the Harvest have been derived from returns which appeared in the *Agricultural Gazette*, July 29 to August 26, 1907.

TABLE VII.—Estimated Yield of Fruit Crops in 1907.

Description of Crop.	England.						Scotland.	Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H, J, and K W. E. and N.	B and G S. and N.	
Apples	-	-	-	-	-	-	-	-	-
Pears	-	-	-	-	-	-	-	-	-
Plums	0	+	+	+	-	+	-	-	+
Raspberries	+	+	+	+	+	+	+	+	+
Currants	+	+	+	+	+	+	+	+	+
Gooseberries	+	+	+	+	+	+	+	+	+
Strawberries	0	0	-	-	-	-	+	0	-

Symbols:—+ = Over. - = Under. 0 = Average. This Table has been compiled from returns which appeared in the *Gardeners' Chronicle*, August 3, 1907.

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TABLE VIII.—Variations from the Average in Mean Temperature, Rainfall, and Sunshine, 1906-7.

Winter 1906-7.

Temperature.

Months.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
December	−1·2	−0·4	−1·9	−1·1	−2·3	−1·0	+0·2	−0·9	−1·3	−0·1	−0·6
January	−2·0	−0·4	−1·2	−0·9	−1·0	−1·0	+0·3	−0·6	−1·4	−1·0	−0·7
February	−2·4	−0·9	−1·9	−0·9	−1·1	−1·3	−0·8	−0·8	−0·4	−0·2	−0·5
Winter	−1·9	−0·6	−1·7	−1·0	−1·5	−1·1	−0·1	−0·8	−1·0	−0·4	−0·6

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
December	−0·9	−1·4	−0·8	−0·1	+0·1	+0·3	0·0	−0·4	+0·1	+0·5	0·0
January	−1·7	−2·8	−1·3	−1·3	−0·6	−1·4	−1·3	−1·8	−1·0	−1·1	+0·3
February	−0·6	−1·0	−0·5	−0·4	−0·2	0·0	−0·1	+0·3	−0·1	−0·1	+1·8
Winter	−3·2	−5·2	−2·6	−1·8	−0·7	−1·1	−1·4	−1·9	−1·0	−1·7	+2·1

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December	+ 6	− 6	+11	+12	+ 8	+10	0	+ 3	+11	+ 3	−11
January	+13	−16	+16	+17	+17	+14	− 9	− 8	+34	+ 8	− 8
February	− 1	+ 6	+10	+17	− 3	+21	+ 8	+18	+30	+31	+ 9
Winter	+18	−16	+37	+46	+22	+45	− 1	+13	+75	+42	−10

Spring 1907.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
March	+1·1	+2·8	+1·2	+2·0	+1·3	+1·9	+2·3	+1·8	+2·1	+1·9	+1·5
April	−0·9	−0·9	−0·3	+0·3	+0·7	−0·2	−0·6	0·0	+1·0	0·0	+0·5
May	−1·5	−1·9	−1·1	−1·1	−0·2	−1·4	−1·8	−1·5	−0·6	−2·5	−1·2
Spring	−0·4	0·0	−0·1	+0·4	+0·6	+0·1	0·0	+0·1	+0·8	−0·2	+0·3

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
March	−1·0	−0·7	−0·8	−0·5	−0·4	+0·7	+1·6	+0·8	−0·6	−0·2	+1·5
April	+1·7	+0·4	+1·5	+0·3	+0·4	−0·6	+0·1	+0·2	0·0	+0·1	−0·1
May	+0·8	+1·0	+0·6	+1·3	+1·1	+0·8	+1·9	+1·8	+2·0	+1·2	+0·7
Spring	+1·5	+0·7	+1·3	+1·1	+1·1	+0·9	+3·6	+2·8	+1·4	+1·1	+2·1

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March	+36	+16	+77	+60	+75	+59	+24	+77	+80	+45	+10
April	− 7	−20	+10	−10	− 7	+ 3	−20	−10	+12	+14	+11
May	−70	−31	−53	−60	−33	−70	−35	−47	−45	−72	−26
Spring	−41	−35	+34	−10	+35	− 8	−31	+20	+47	−13	− 5

+ indicates above the average, − below it.

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TABLE VIII.—VARIATIONS FROM THE AVERAGE—*continued.*

SUMMER 1907.

Temperature.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
June	−3·6	−3·1	−2·7	−3·0	−1·1	−3·2	−3·8	−3·4	−1·1	−3·3	−2·6
July	−2·3	−0·3	−3·6	−3·4	−3·7	−2·3	−1·0	−0·6	−3·2	−3·3	−1·6
August	−0·9	−0·6	−1·1	−0·8	+0·1	−1·5	−1·6	−1·6	−0·2	−2·5	−2·4
Summer	−2·3	−1·3	−2·5	−2·4	−1·6	−2·3	−2·1	−1·9	−1·5	−3·0	−2·2
					Rain.						
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
June	+1·4	+1·1	0·0	+0·4	−0·3	+2·8	+2·0	+2·3	+0·8	+1·3	+2·0
July	+0·2	+0·2	−0·7	+0·9	−0·7	−0·6	−0·4	−1·1	−1·4	−0·5	−1·2
August	−0·7	−1·2	−0·6	−0·7	−1·1	+0·2	−0·4	+1·0	−0·6	+0·3	+2·0
Summer	+0·9	+0·1	−1·3	+0·6	−2·1	+2·4	+1·2	+2·2	−1·2	+1·1	+2·8
					Sunshine.						
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June	−77	−56	−33	−30	−40	−63	−47	−78	−11	−37	−44
July	+7	+30	−15	−26	−30	−2	+30	+8	−18	−45	−4
August	−34	−14	−3	0	−11	−9	+8	−3	+21	−9	−16
Summer	−104	−40	−51	−56	−81	−74	−9	−73	−8	−91	−64

AUTUMN 1907.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
September	+1·6	+2·8	+1·2	+1·3	+1·1	+1·7	+1·8	+1·2	+1·2	+0·7	+0·7
October	+0·4	+0·4	+2·2	+1·8	+3·2	+1·0	+1·3	+1·4	+2·1	+1·3	+1·4
November	0·0	−1·4	+1·3	+0·9	+2·0	−0·2	−0·3	−0·9	+0·4	+0·2	0·0
Autumn	+0·7	+0·6	+1·6	+1·3	+2·1	+0·8	+0·9	+0·6	+1·2	+0·7	+0·7
					Rain.						
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
September	−1·6	−1·1	−1·5	−1·2	−1·5	−2·1	−1·5	−2·6	−1·3	−1·0	−1·8
October	+2·5	+2·0	+2·2	+2·3	−0·3	+0·8	+0·3	+0·8	+1·5	+2·4	−2·8
November	−0·5	−0·4	−0·4	+0·1	+0·1	−0·2	−0·7	−0·6	−0·2	−0·7	−0·4
Autumn	+0·4	+0·5	+0·3	+1·2	−1·7	−1·5	−1·9	−2·4	0·0	+0·7	−5·0
					Sunshine.						
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September	+23	−15	+34	+28	+41	+20	−15	+9	+54	+51	+29
October	−12	−34	−16	−5	−14	+4	−21	−23	+5	−14	+5
November	+4	+9	−1	+6	−8	+5	+21	+8	+9	+14	+11
Autumn	+15	−40	+17	+29	+19	+29	−15	−6	+68	+51	+45

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

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TABLE IX.—Supplementary Observations in 1907.

BIRDS.

Chiff-Chaff (first heard).

Station.	District.	Date.
Mawnan	A	April 1.
Bagenalstown	B	March 24.
Ovoca	B	,, 26.
Ardgillan	G	,, 27.
Edgeworthstown	G	,, 28.

Corncrake (first heard).

Station.	District.	Date.
Bridgend	A	May 8.
Whitney-on-Wye	A	,, 17.
Ovoca	B	,, 7.
Ripley	D	,, 13.
Cronkbourne	F	,, 10.
Chanter Hill	G	April 22.
Altnafoyle	G	,, 30.
Tardington	H	May 29.
Moniaive	H	,, 8.
Thirsk	I	,, 10.
Corbridge-on-Tyne	I	April 23.
Durris	J	May 11.

Swift (first seen).

Station.	District.	Date.
Brixham	A	May 10.
Bridgend	A	,, 5.
Ovoca	B	,, 5.
Cranleigh	C	,, 18.
Churt Vicarage	C	,, 5.
Harefield	D	,, 24.
Dymock	D	,, 6.
Ripley	D	,, 5.
Odsey	E	,, 14.
Altnafoyle	G	,, 12.
Corbridge-on-Tyne	I	,, 18.
Durris	J	,, 19.

PLANTS.

Winter Aconite.

Station.	District.	Date.
Whitney-on-Wye	A	Feb. 18.
Cambridge	C	Jan. 16.
Churt Vicarage	C	,, 17.
Watford	D	,, 8.
Berkhamsted	D	Feb. 11.
Clenchwarton	E	Jan. 7.

(D)—Oats were first cut on the 2nd, and wheat on the 9th. *Harefield* (D)—5th. Oats first cut. 11th. Swift last seen. 29th. Wheat first cut. *Farnborough* (D)—Scarcely any butterflies all the summer. *Northampton* (D)—Some hay not carried before the middle of the month. *Hodsock* (D)—10th. Hay harvest finished. 16th. Oats cut. *Ripley* (D)—27th. Swift last seen. *Odsey* (*Ashwell*) (E)—15th. Wheat cut. 21st. Barley cut. 30th. Oats cut. *Bocking* (E)—16th. Harvest began. *Lexden* (E)—The usual autumn butterflies almost non-existent here, but wasps were extremely numerous. *Clenchwarton* (E)—19th. Very few wasps. 30th. Leaves of wych elm turning colour. *Llangollen* (F)—Hay harvested in fair condition. *Cronkbourne* (F)—27th. Harvest began. *Antrim* (G)—Very few butterflies, wasps, or house-flies. 20th. Swift last seen. 22nd. A brood of swallows left their nest. *Thirsk* (I)—14th. Hay harvest completed. 28th. First corn cut. *Beauly* (K)—Much hay harvested in good order during the third week.

September.—*Altarnon* (A)—The straw of corn crops heavy everywhere. *Whitney-on-Wye* (A)—Potatoes much diseased. Blackberries a failure. *Ovoca* (B)—On the whole a very poor harvest. Very few wasps and not many butterflies. *Churt Vicarage* (C)—10th. The early autumn flowers particularly full of bloom. 23rd. Dahlias and French beans destroyed by frost in lower parts of the parish. *Ditton Hill* (C)—All fruits this year are wanting in flavour. Potatoes considerably diseased. *Farnborough* (D)—1st. An abnormal number of earwigs. *Beeston* (D)—Very few butterflies, but plenty of earwigs. *Hodsock* (D)—6th. Enormous crops of plums. 24th. Corn harvest finished. *Macclesfield* (D)—Gardens looked brighter and the flowers were more abundant at the end of the month than at any time in the year. *Bocking* (E)—24th. Harvest

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finished. *Southacre* (E)—19th. Harvest finished. *Clenchwarton* (E)—27th. Harvest finished. *Llangollen* (F)—Splendid weather for early harvests. *Betley* (F)—13th. Oats carried. *Cronkbourne* (F)—4th. Dahlias slightly blackened by frost. *Moniaive* (H)—3rd. Potatoes, holly, bay, phlox, etc., blackened by frost. *Thirsk* (I)—4th. Marrows and kidney beans killed by frost. *Aberdeen* (I)—Two or three weeks in this month the only genial ones in the whole year.

OCTOBER.—*Altarnon* (A)—31st. Second crop of grass very good. *Whitney-on-Wye* (A)—16th. Dahlias and beans blackened by frost. *Bagenalstown* (B)—23rd. Gathered a dish of peas. *Churt Vicarage* (C)—25th. My dahlias were destroyed by frost. *Harefield* (D)—20th. Martin last seen. *Dymock* (D)—8th. Dahlias blackened by frost. *Hodsock* (D)—8th. Peas have very little flavour. 13th. A large crop of apples. 21st. Gathered a dish of peas. *Clenchwarton* (E)—16th. A nest of young swallows ready to fly. 20th. Blackberries plentiful, but small and still green. *Llangollen* (F)—Weather bad for late harvests and working the land. *Saintfield* (G)—31st. Much corn still in the fields. *Thirsk* (I)—21st. Quite half of the corn in this district still out in the fields and some not cut.

NOVEMBER.—*Altarnon* (A)—Very late defoliation of many trees. *Tiverton* (A)—32 wild flowers and 63 garden flowers were in blossom during the month. 1st. A large peach gathered out of doors. 6th. Half a pint of blackberries gathered. *Aberystwith* (A)—21st. Dahlias killed. *Whitney-on-Wye* (A)—Many leaves still on the trees at the end of the month. *Churt Vicarage* (C)—15th. Autumn tints not so bright as usual. *St Albans* (*New Farm*) (D)—Geraniums and heliotropes in flower until the 22nd. All the deciduous trees kept their foliage later than usual. *St Albans* (*Glenferrie Road*) (D)—Holly-trees laden with berries. *Berkhamsted* (D)—16th. Dahlias killed by frost, 10 days later than the average date of their destruction in the previous 22 years. *Farnborough* (D)—*Daphne mezereon* in bloom. *Hodsock* (D)—5th. Autumn tints showing a little, but never really good. *Odsey* (E)—1st. Common elms in full leaf. 5th. Half of the foliage yellow. 9th. Have lost but few leaves. 19th. In exposed places they retain but a sprinkling of their leaves. 30th. Still a few leaves on the common elm. Other trees virtually bare. *Clenchwarton* (E)—30th. Roses still in bloom. *Llangollen* (F)—Corn still unharvested on upland farms. *Betley* (F)—6th. Never saw flowers in the garden in such profusion so late in the year. *Thirsk* (I)—10th. Harvest not yet completed on upland farms. *Durris* (I)—Unprecedented length of harvest. *Aberdeen* (J)—Much harvest work had to be done this month. *Beauly* (K)—Last corn secured in fair condition by the middle of the month.

DISCUSSION.

Mr. R. H. HOOKER congratulated Mr. Mawley on his Report. These papers were always very interesting, and Mr. Mawley's summary of the whole season was admirable. He wished to call attention to one point, and that was the apparent failure of Dr. Shaw's relationship between the autumn rainfall and the wheat supply. This failure was only apparent. Fifteen months ago, he (Mr. Hooker) had gone thoroughly into the question. He had taken Dr. Shaw's point and extended it over other crops and weather at different parts of the year. The result had confirmed Dr. Shaw's opinion. In the autumn of 1906 the rainfall was above the average, but not very much, and he had come to the conclusion that the probable deficiency of the wheat yield due thereto was about 1 bushel per acre. There were, however, two abnormal seasons affecting the harvest of 1907, viz.: the cool spring and summer, and the hot summer of

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the preceding year. Each of these probably accounted for an increase of 2-3 bushels, against which had to be set the deficiency due to the wet autumn, leaving something like 4-5 bushels per acre above the average as the effect of the whole period. The chief feature of the year had been the very cool spring and summer, which he thought conduced to bulk in nearly all crops. The beautiful summer of 1906 had also had a good influence upon the grain seeds, and these two factors accounted for the very great abundance of nearly all crops in 1907.

Mr. F. C. BAYARD said he had listened with great interest to Mr. Mawley's report. In 1891 Mr. Mawley had taken a mean of the previous 8 years, and after that he commenced taking the means from 1891 up to the present time. He (Mr. Bayard) considered it might be an advantage if the mean of the first 8 years were added to the mean for 1891 to 1907. They would get an average of 25 years. Mr. Mawley had mentioned that wasps were a day late; they were very scarce during the summer, but in September they were very great in number.

Mr. H. MELLISH remarked that he would like to know whether Mr. Mawley had received any reports upon the extraordinary number of small flies in the early autumn of last year. As regards the large produce of so many crops last year, in many of the late districts these were scarcely harvested at all. He himself had watched one field of wheat which was only harvested just before Christmas. In the North things were still worse. The total yield might have been very good, but a great deal of the harvest must have been got in in a bad condition. The value of the produce was only calculated on the price of the best samples.

Mr. W. W. BRYANT remarked that at the Royal Observatory, Greenwich, he had noticed a magnolia flowering twice, the second time fairly late in the year. He had not known this to happen before.

Mr. C. HARDING said he hoped Mr. Mawley would stay his hand in the execution of one threat, and that was when he said that he would delete the early years of the diagram which he showed for 17 years for different districts. Rather than cut out any of the years he would suggest that Mr. Mawley might make five-yearly averages of them. He thought the great value of these observations lay in the long period over which they extended.

Mr. J. E. CLARK said he had heard that the honey crop was a failure, probably because it depended entirely upon the weather of the months which were so specially cool, May to July. He thought one reason of the reports of ruin was because the farmers, like others, were apt to cry out when things went wrong, but kept quiet when everything was going right. The after effects of the season were also interesting, as shown in the condition of the flowering plants at the end of the season. Last year there had been practically no frost, and very little of the flowering plants had therefore been destroyed. He had taken observations of the number of flowering plants in his garden, and there had not been so much difference as might have been anticipated between 1906 and 1907, though the latter year showed greater profusion. Mr. Clark then gave some comparative figures concerning plants, remarking that last year he had at Christmas 50 garden and 45 wild plants. Many roses in December were still in bloom. The totals for January of last year had come out more than for this year, being 23 this year and 26 plants last year. The frost in February had reduced the number still more.

Mr. E. MAWLEY in reply said he was much interested in the remarks made by Mr. Hooker upon the probable effect of the different seasons upon agricultural produce. He was, however, still of opinion that Dr. Shaw's theory had not been last year borne out by the results of the harvest. Dr. Shaw's theory, as originally stated, was that the yield of wheat in one year was in

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inverse proportion to the quantity of rain deposited during the previous autumn. Whereas the yield of wheat in 1907, and also the rainfall of the autumn of 1906, were throughout the corn-growing districts of England in excess of the average. In answer to Mr. Bayard he need only say that previous to 1891 the observations of the 13 plants were in no district sufficiently numerous to be of any service in a comparative table like Table I.

Mr. R. H. HOOKER said that Mr. Mawley had apparently misunderstood his remarks about Dr. Shaw's calculations. The autumn period of the year had been swamped by other periods which happened in 1907 to be of more importance.

The Climate of Davos.

We have received from Dr. Hugo Bach a pamphlet on this subject, which forms Bd. xlii. 1 of the *Neue Denkschriften der Schweizerischen Naturforschenden Gesellschaft*. The paper is based upon the material furnished by the Meteorological Station at Davos, and, in addition to its tables, curves, and summaries contains a discussion on the hygienic aspects of the Davos climate. Of the general points which emerge from the investigation, the most important is the emphasis which the author lays upon the distinction to be drawn between the climate of an elevated valley and that of a mountain summit. As is well known, a mountain climate tends to approach the insular type, but the Davos observations show that the elevated valley climate approaches nearer the continental type. As regards the different climatic elements, the pressure, as it is to be expected from the elevation, is low, and the variations relatively small. As in other elevated regions, the maximum falls in the summer, not in the colder months as at lower levels. The valley is sheltered from the wind, and calms are frequent. The amount of cloud reaches its minimum in winter, and is small as compared with towns in the plain, *e.g.* Zürich, and with mountain summits, like the Rigi-kulm. The low pressure results in a low humidity of the air; in winter, especially, the difference between the amount of atmospheric moisture in the Davos valley and in the low ground is enormous. As a result again of this, and also of the broad shape of the valley, and of the reflecting snow mountains around, insolation is very strong. This insolation again gives the climate an extreme and thus a continental character. Not only does it produce a well-marked effect on the summer and winter means, but it also produces marked diurnal variations of temperature in objects exposed to the sun's rays. At the Schatzalp Sanatorium, which is placed about 300 metres [1000 ft.] above the floor of the valley, both the daily and the annual variations are less marked than at Davos, *i.e.* this station approaches nearer the mountain type of climate. On the other hand it is to be noted that severe shade temperatures can be much more readily tolerated here than on lower ground, owing to the stillness of the dry air and its feeble conductivity. The mean annual precipitation is about 910 mm. (36 ins.), that is, not much more than half that of such places as Lucerne and Lugano (1710 mm.) [67 ins.]. The continental character of the precipitation is especially shown in the time of fall, for while the summer is wet, the winter means, and especially the January means, fall far below those of lower stations. Thus the mean January fall at Davos is under 2 ins. (46 mm.).

As regards the physiological effects of the Davos climate, especially on persons in delicate health, the only point which we can mention here is that the evidence seems to show that the active agents do not appear to be exclusively the meteorological elements as usually measured. It is possible that other factors, such as the electrical condition of the air, and its radioactive emanations, intervene to complicate the problem.—*Scottish Geographical Magazine*, August 1908.

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Vincent's Cloud Atlas.

M. J. Vincent, the Meteorologist of the Royal Observatory, Brussels, has given in the *Annales* of the Observatory, Tome 20, an "Atlas des Nuages," or Cloud Atlas. This atlas, he states, has been compiled with the object of making public, especially among observers, a knowledge of the classification published in the International Meteorological Committee's Cloud Atlas in 1896. He has, however, expanded this, and added other forms which, although of secondary importance, he considers should be included. Certain species have also been subdivided into several varieties, the greater part of which have, however, already been described by other authors. He gives an account of the form, relative altitude, and, as far as possible, the origin of the condensations of the various forms of cloud.

He divides the clouds into three groups: (1) Lower, (2) Middle, and (3) Upper. He further subdivides these into the following varieties:—

LOWER CLOUDS.

Species.	*Varieties.*	*Species.*	*Varieties.*
Fumulus		Nimbus	Tonitro-nimbus
Cumulus	Fracto-cumulus	Cumulo-nimbus	Fasciculus
	C. simplex	Stratulus	
	C. congestus	Pileus	
	C. compositus	Nimbo-stratus	
	Pallio-cumulus	Strato-cumulus	Pallio-strato-cumulus
	C. humilis		Fracto-strato-cumulus
	C. pendulus	Stratus	Fracto-stratus
Nimbus	Pallio-nimbus		Stratus cumuliformis
	N. cumuliformis		Stratus hiemalis
	Fracto-nimbus		

MIDDLE CLOUDS.

Species.	*Varieties.*	*Species.*	*Varieties.*
Alto-cumulus	A. cu. pulvinatus	Alto-cumulus	A. cu. incertus
	A. cu. frixus		A. cu. margarodes
	A. cu. floccus		A. cu. castellatus
	A. cu. sphericus	Alto-stratus	
	A. cu. granosus	Virgulus	
	A. cu. corrosus	Cirroides	

UPPER CLOUDS.

Species.	*Varieties.*	*Species.*	*Varieties.*
Cirrus	C. filosus	Tracto-cirrus	T.-c. implexus
	C. uncinus		T.-c. floccosus
	C. fascigerus		T.-c. lactosus
	C. implexus	Cirro-stratus	C.-s. fascigerus
	C. confertus		C.-s. implexus
	C. floccosus		C.-s. floccosus
	C. lactosus		C.-s. lactosus
Tracto-cirrus	T.-c. filosus		C.-s. informis
	T.-c. pennatus	Cirro-cumulus	
	T.-c. vertebratus		

M. Vincent gives twenty-eight photographic reproductions of various forms of clouds, which were taken at the Royal Observatory, Uccle, Brussels. These are extremely interesting, and are likely to be of great assistance to observers in identifying many forms of clouds.

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UPPER AIR OBSERVATIONS IN EGYPT.

By B. F. E. KEELING, M.A., F.R.A.S.

[Read May 20, 1908.]

The President has invited me to describe to you the lines on which we are conducting the investigation of the upper air in Egypt. In the present paper it is my intention to give a brief account of the methods we are using at present, and of the directions in which we hope, in the near future, to develop the work. In no country in the world can the problems of commercial value which meteorologists have to solve be stated more simply. The whole justification from the practical point of view of a meteorological organisation in Egypt is the hope that in the end some power of forecasting the state of the Nile may be acquired. In Egypt itself there is comparatively little weather at all, and what there is has no influence commercially except along a narrow belt on the Mediterranean coast, but, on the other hand, the whole prosperity of Egypt is wrapped up in the weather of the neighbouring country of Abyssinia. As the summer rainfall is greater or less in Abyssinia, so is the Nile flood, and, in consequence, the area of land cultivated and the general prosperity greater or less. In years in which, following a bad flood, a bad low stage of the river is to be expected, the early spring showers in Abyssinia are also of very great importance.

Unfortunately there is not, nor for some time is there likely to be, a meteorological service in Abyssinia. It is true that some observations have from time to time been made at Adis Ababa, but anything like a systematic study of the climate and weather in Abyssinia is, for the moment, beyond hope. The result is that we have in the main to be content with indirect lines of research. We have but very imperfect information about the Abyssinian rainfall, so we have to consider the effect of that rainfall, the Nile flood, and to study its relationship with the meteorological conditions prevailing in such of the surrounding countries as have meteorological services. Some progress is undoubtedly being made. Thus, Captain Lyons has shown that there is an apparent, but not very consistent, connection between the summer barometric pressure at Cairo and the following Nile flood.

But it is evident that little advance can be made so long as our observations are confined to the surface, and that it is of the utmost importance to acquire a knowledge of the general atmospheric circulation over the whole area surrounding the rainfall area. This is, of course, stating the matter from the purely local point of view, apart from the value of the work in the general international scheme of Upper Air investigation.

A start was made last summer by establishing an aeronautical station at Helwan Observatory. The observatory is situated on the desert plateau to the east of the Nile, about 25 kilometres (15 miles) south of Cairo, and some 6 kilometres (4 miles) from the river. The principal buildings are 100 metres (330 ft.) above the level of the river.

Up to the present two lines of experiment have been taken up. The first, and I think the most important, is the flying of pilot balloons for

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the determination of the direction and velocity of the upper currents. The balloons at present in use are india-rubber ones made by M. Paturel, and are filled with hydrogen to a diameter of about 70 centimetres. The hydrogen is prepared from zinc and sulphuric acid, and is washed and dried on its way to the balloon. The balloons are watched by two observers using the very convenient form of theodolite made by Bosch of Strassburg. We are at present using a base-line rather over 3 kilometres (2 miles) in length, one station being on the tower of the Observatory and the other on a hill in the desert.

Theodolite readings are taken simultaneously at intervals of a minute, the watches used being compared before the experiment. The staff at each station consists of one observer to keep the telescope on the balloon and to read the vertical circle with his disengaged eye, a native clerk to read the horizontal circle and to book the readings, and two native chainmen, one to call the time, and the other to hold an umbrella over the theodolite and observer. The theodolite is surrounded by a square wind-screen.

The height of the balloon and the distance away from the point from which it is released are computed for each minute, and are then plotted on special angle paper, which has been lithographed in the printing office of the Survey Department. For convenience of reference, the trajectories thus obtained are reduced on to cards with the aid of a pantagraph.

The observations have only been in progress for a few months, and it is too early yet to enter on a statistical examination of the results, which are published monthly in the *Cairo Scientific Journal*. It may, however, be stated that the observations of the anti-trade winds made by Teisserenc de Bort and Rotch have been confirmed. At Helwan (lat. 30° N.), the anti-trade wind is reached at a height of about 2000 metres (6500 feet) above sea-level. Given favourable atmospheric conditions, the balloons can be followed to a distance of from fifty to seventy kilometres (thirty to forty-four miles), the height to which they are observed depending, of course, on the character of the wind currents. The greatest height so far reached is 16,500 metres (54,000 feet), and it is of importance to note that on this occasion the South-west anti-trade wind was apparently penetrated and a North-west upper-current encountered.

We have also commenced work with kites. On a plateau behind the Observatory two galvanised iron sheds have been built, one to hold the machinery, and the other a number of kites which are kept strained ready for use. The kite-winch was made by Mr. Cook, mechanic to Manchester University, from designs by Mr. W. H. Dines, F.R.S., and Mr. J. E. Petavel, F.R.S. It is driven by a 3½ h.p. Crossley petrol motor. The whole works admirably, and from the start very little trouble has been experienced. The kites and meteorographs have been supplied by Mr. Dines. In kite-flying we are greatly hampered by the very low wind velocities which are usual at the surface, and by the rather common occurrence of calm-belts, which are often met with even when there is a kite-flying breeze on the ground.

Observations on the air currents in Central Africa during the rainy season are much needed, and it has been arranged for me to spend the month of August at Mongalla (latitude 5° N.). I am taking up with me apparatus for work with both pilot balloons and kites, though it is

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unlikely that there will be more than two or three days on which we shall be able to use the latter, as the winds are as a rule exceedingly light. On my return in September I shall probably make a few days' observations at Port Sudan on the Red Sea coast.

I hope that during next winter our investigations may be considerably developed. It is intended, in the first place, to examine in greater detail the direction and velocity of the wind in the lower strata of the atmosphere to a depth of 2000 or 3000 metres (6500 or 10,000 feet). In Egypt surface winds are usually very light, and are greatly influenced by very local circumstances.

We frequently find that observations of the wind at the surface are no guide to the nature of the wind at an altitude of only 100 or 200 metres (330 or 650 feet). A striking example of this was furnished by two pilot balloon flights made last December at Aswan. Here a North wind is recorded on almost every day in the year. On the days of observation this North wind was found to be only 200 metres (650 feet) thick, being succeeded by a due East wind.

For this study of the lower strata it is proposed to send up small pilot balloons daily, using a short base of 500 metres (1650 feet). The long distance balloon flights will be continued five or six times monthly I hope that it may also be possible to occasionally send up balloons at Alexandria and at Aswan, where the interesting ascents in December would appear to justify systematic observations being made. The smallness of our staff will, however, be a difficulty, and I hope that any British meteorologist wishing to spend a winter abroad will come and make upper air observations at Aswan.

I hope also that the research into the temperature and humidity gradients may be extended, but here, as I have remarked before, there are considerable difficulties in front of us owing to low wind velocities. We may perhaps be able to improve matters by changing our form of kite, and perhaps by having 1000 or 2000 metres (3300 or 6500 feet) of lighter wire for the first kite. In Europe and America the use of ballons sondes has greatly extended the information about the temperature gradient. In Egypt, however, owing to the peculiar geographical conditions it does not seem possible to make use of them to the best advantage. If a balloon were sent up at Helwan the instruments would invariably fall many miles in the desert, and the chances of recovery would be infinitesimal. If ascents were made in the Delta, although some percentage of the balloons would burst above the cultivated area, it is exceedingly doubtful whether more than a very few of these would be returned. I think for the present we shall have to limit our ambitions to the first 5000 or 6000 metres (16,000 or 20,000 feet), sending up instruments attached to balloons, and fitting some form of time-fuse, so that after twenty or thirty minutes the instruments would be released. A small balloon would be attached to and fall with the instruments, and would act as a signal flag to facilitate recovery.

DISCUSSION.

Mr. C. J. P. Cave said that he congratulated Mr. Keeling heartily on the work he had done in Egypt. It was a very interesting place on account of the

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clearness of the air. With regard to the high ascent referred to by Mr. Keeling it was probable that the balloon went through the South-west anti-trade into the isothermal zone. Very few observations had been made of the drift of balloons in the isothermal zone, and he hoped that Mr. Keeling would be able to repeat observations at this height. Mr. Cave said that he noticed on some of the diagrams that the wind backed with increasing height; in this country it usually veers at first. He was interested to notice the decrease in velocity which occurred between winds from different directions; he had noticed the same phenomenon in this country. He wished to ask whether the vertical velocity varied much; he himself had found that the vertical velocity was variable when the balloon was in a bad position with regard to the base line, in other words the apparent departures from a uniform ascensional velocity were mainly due to errors of observation.

Dr. W. N. Shaw said that observations of the upper air were a very attractive subject, and Mr. Keeling's presentation of the subject both in his paper and diagrams was excellent. He hoped Mr. Keeling, however, would not write off the surface winds as bad debts; they were extraordinarily annoying, but there must be something in them. It would be a great pity if they were disregarded as not being worth following. As soon as they could get a real working formula between the actual wind at some level and the pressure gradient at the same level, they would afford an interesting field for study and investigation. He hoped, therefore, that Mr. Keeling would lose no opportunity of pursuing these surface winds as far as possible. A point of great interest about the results was, that although very frequently the upper air current set from the west or south-west, there were occasions when it set from the north; that must be a circumstance interesting to Egypt and other parts of the world meteorologically connected with Egypt. He could not account for the northerly set of the wind in the upper air over Egypt; before attempting an explanation it would be necessary to know the set of the upper air at other places.

Colonel H. E. Rawson remarked that he would ask Mr. Keeling to bear in mind, when he went down south in August and September, that he would be dealing with a region in which the equatorial belt was over him. When he came a little further north, he would leave that belt and get into the edge of the northern anticyclonic belt, where the conditions of the upper air were different. These changes of wind appealed to two sections of his audience, and were very interesting to those like himself who wished to know more about the lower surface winds, and to those who were less interested in the surface than in the upper currents. It was important to know what was going on in Egypt when the change took place from the anticyclonic to the equatorial belt and *vice versa*, and he welcomed this contribution.

Mr. E. S. Bruce said that he thought it might be desirable to try some lighter forms of kites in Egypt. Some very creditable ascents had been made with light ones. The ordinary box-kite was perhaps unsurpassed in a stiff breeze, but on days when there was not enough wind for it, lighter forms of kites had been flown successfully. Mr. Salmon's eighteen-wing kite appeared to be a good form for light winds, and at the kite display last summer had reached an altitude of about 3000 feet, though the wind was very light.

Mr. B. F. E. Keeling, in reply, thanked the Fellows for the way in which they had received his paper, and also those who had spoken, showing that work was being done which proved of interest to meteorologists. He wished it were possible to tackle the whole question of surface winds, but they could devote very little time to this work, which could only be done in the slack season in Egypt. However, they were making a definite start in the question. With regard to Mr. Cave's question, he found in the lower strata that the wind had

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a tendency to veer, but it backed as it went into the upper air, 2000 to 3000 metres above. First there was a veering, and then a backing. As to the changes of vertical velocity, he entirely agreed.

THE PRESIDENT, Dr H. R. MILL, expressed the thanks of the Society to Mr. Keeling for his most able exposition of his extremely interesting and capably carried out investigations on the upper air. It was the beginning of experiments in the branch of meteorology which at present occupied the chief place in the development of the science. Judging from the activity of all parts of the Survey Department, it would almost seem that Egypt would once more become the scientific centre of the world, as it was thousands of years ago.

Tree set on Fire by Lightning.

A wych-elm was struck during a recent thunderstorm in Morhanger Park, near Sandy, Beds. It was set on fire, and smouldered for about a fortnight, when it was cut down. On being opened the centre of the trunk was found to have been converted into charcoal and at the bottom of the burnt part, where a sort of pocket had been formed, was found a greyish-white ball about six inches or so in diameter. On cooling it broke easily. It was naturally supposed to be a thunderbolt, but the lady of the house told me she was sure there were no such things. She was, however, very much puzzled as to what it could be, and so was I; so I had a piece analysed and found it consisted of calcium carbonate with traces of magnesium and iron. It was therefore obviously a product of the tree and not of the lightning, and would be formed by the wood being consumed in what was practically a crucible or retort.

The fire was confined to the interior of the trunk, and there were no marks of damage on the exterior. It is rather a rare thing for a tree to be set on fire by lightning, but I have come across several cases, and in each have found that the injury has been confined to the interior in this way. It is rather remarkable that a growing and healthy tree should be set on fire, and I do not see how it can be accounted for. A highly resisted discharge is more likely to cause fire than one given a fairly easy path, but we should not expect one tree to be so very much more highly resisting than another.

A discharge often keeps to the bark, when there is generally only a groove cut in it, and the tree may not be killed; or if it goes through the body of the tree, the sap is turned into steam and the tree is split to pieces by the explosive effect. In the Morhanger case there appears to have been no explosive effect, yet heat enough to cause fire.

I recently came across a case in which the bark of a tree had been almost entirely torn off, only a narrow strip being left, and this was loose, merely holding by a few fibres. The trunk was left white, and resembled a banana with the peel turned back. This is the first instance of the kind that I have seen.

At the house where I was stopping last week-end in Suffolk, I was shown two thunderbolts (!) that had been found when digging a well. The only reason for supposing them to be thunderbolts was that no other explanation was available. I was unable to say what they were. They appeared to be parts of hollow burnt clay balls very roughly fashioned, and may have been first attempts of some of our ancestors to make earthenware vessels. Perhaps this guess may be as wild as the one that attributed them to lightning.—ALFRED HANDS, 91 Leadenhall Street, E.C., *September* 11, 1908.

Meteorological Investigation in Africa.

According to a message from Rome, Professor Palazzo, Director of the Central Italian Bureau of Meteorology, was to start early in July for Zanzibar

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in order to take part in an international scheme for the study of the monsoon winds on the coasts and in the interior of East Africa. At Zanzibar the professor will embark on the torpedo cruiser *Caprera*, from which he will make a series of meteorological studies, partly by means of balloon ascents along the coast.

Simultaneously, British, French, and German expeditions will proceed to the sub-tropical zone of the interior to engage in similar operations there. The most important of these expeditions is undoubtedly the German, which has been organised under the immediate patronage of the Emperor William, His Majesty contributing 50,000 marks (£2500) for the purpose of meteorological research on the Victoria Nyanza; and Professor Palazzo's mission on the coast will be especially connected with the work of this party.—*Scottish Geographical Magazine*, August 1908.

The Climate and Vegetation of Panama.

In *Science* for March 27 an abstract is given of a paper by Dr. R. E. B. M'Kenney on this subject. The differences between the Atlantic and Pacific sides of the Republic are very striking. On the Atlantic side there is no distinct dry season, though less rain falls in February and March than in the later months of the year. In the months of our winter the average temperature varies from 88° to 92° or 93°, and in our summer from 92° to 95°, the minimum temperatures being 60° and 65° respectively. In the Pacific province of Chiriqui, separated from the Atlantic side by the mountain backbone, the temperature range is about the same, but there is a very distinct dry season which lasts five or six months, and during which the vegetation becomes parched and dry. On the Atlantic side, notably at Bocas del Toro, the region studied, the vegetation is luxuriant, with almost impenetrable jungles, mangrove swamps along the sea-coast, and thickets of giant stemless palms. Further inland are forests of palms and exogenous trees, overgrown with aroids and other climbers. On the Pacific side, on the other hand, there are stretches of grass and sharply outlined patches of shrubs, agaves, and species of cactus. At Bocas del Toro bananas are now very extensively cultivated.—*Scottish Geographical Magazine*, August 1908.

Heavy Rainfall in Japan.

In the April number of the *Journal of the Meteorological Society of Japan* an account is given of a very heavy rainfall that occurred in August 1907, and continued for 3 to 7 days in different parts of Japan, and caused a great amount of damage. According to the reports, the regions which had the heaviest rainfall were:—

Western Japan—

Tamba and Tango regions: 13·31 ins. in 1 day, and 20·95 ins. in 2 days.
Eastern part of Kii Peninsula: 13·03 ins. in 1 day; 17·64 ins. in 2 days; and 20·71 ins. in 3 days.
Eastern part of Awa: 8·86 ins. in 1 day, and 13·86 ins. in 2 days.

Eastern Japan—

Western part of Suruga: 14·37 ins. in 1 day, and 23·86 ins. in 2 days.
Central part of Izu: 19·02 ins. in 1 day; 30·01 ins. in 2 days; and 39·92 ins. in 4 days.
Western part of Musashi: 16·34 ins. in 1 day; 26·10 ins. in 2 days; 30·43 ins. in 3 days; and 35·71 ins. in 5 days.
Vicinity of Nikko and Ashio: 7·32 ins. in 1 day; 12·40 ins. in 2 days; and 15·51 ins. in 3 days.

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BALLOON EXPERIMENTS IN BARBADOS, NOVEMBER 6-8, 1907.

Communicated by
PROFESSOR J. P. D'ALBUQUERQUE, M.A.

[Read May 20, 1908].

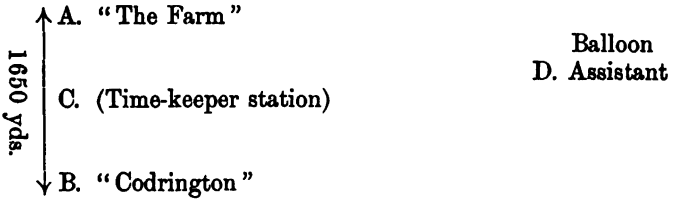
[Sir Daniel Morris, Commissioner of Agriculture for the West Indies, who, at the suggestion of Mr. C. J. P. Cave, kindly undertook to arrange for some balloon experiments to be carried out at Barbados on behalf of the Kite Committee, has forwarded the following Report on the observations made from November 6-8, 1907.—EDITORS].

ONE dozen small balloons and a cylinder of hydrogen were received from the Secretary of the Royal Meteorological Society, with instructions to inflate the balloons with hydrogen and observe their ascent with two theodolites. No further instructions were received, and no one was available with any actual experience of such balloon work. The following course was pursued:—

A Committee, consisting of Mr. J. R. Bovell, F.L.S., Superintendent Botanic Station, and Meteorological observer to the Government of Barbados, Mr. Geo. Lingwood, M.Inst.C.E., Engineer Water-Works Department, Mr. E. F. S. Bowen, M.Inst.C.E., Superintendent of Public Works, and Professor J. P. d'Albuquerque, M.A., Government Chemist, carried out the work, with the help of assistants in their departments.

To ascertain a suitable inflation size for the balloons, a balloon was inflated until it burst, and the circumference, 45 inches, noted. The balloons used in the observed ascents were inflated to a circumference of 35 inches to allow for expansion on ascent.

Three or four balloons were expended in preliminary experiments, and as a result on November 6, two stations were chosen (A) at Codrington and (B) at The Farm, a distance of 1650 yards apart. Each theodolite was worked by three observers, one for the telescope and one for each vernier. By this means it was hoped that the telescope could be kept by one observer constantly on the balloon, while the other two could make "instantaneous" and simultaneous readings at each signal received from the time-keeper, without clamping the telescope. To each theodolite was also attached an attendant to receive the signals. A time-keeper and signaller were stationed at (C) between (A) and (B). The balloon assistant with a signalling attendant took up a point about 2 miles to the north-east of (A) and (B).



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After ascertaining by pre-arranged signals that all the stations were visible one to the other, the balloon was released on a signal from the time-keeper, and half-minute (or in one instance, minute) signals were sent to the theodolite stations until the balloon was out of sight of the time-keeper.

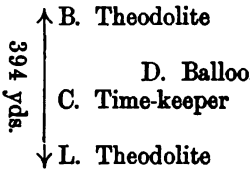
TABLE I.—Balloon Experiments, November 6, 7, and 8, 1907.

Date.	Readings :—Station A. Codrington.					Readings :—Station B.	
	Time.	Last visible.	Horizontal.	Vertical.	Remarks.	Horizontal.	Vertical.
			° ′	° ′			
Nov. 6	Morning	...	...	...	Not seen	Not seen	Not seen
,, 6	No. 1, 3.9 p.m.	...	...	...	Not seen	Not seen	Not seen
,, 7	No. 2, 8.23 a.m.	...	275	2 30	...	Not seen	
	8.23½ ,,	...	256	18			
	8.24 ,,	...	212	31			
	8.24½ ,,	...	159	33			
	8.25 ,,	...	...				
	8.25½ ,,	...	116				
	8.26 ,,	8.27 a.m.	114	24			
,, 7	No. 3, 2.18 p.m.	...	278 30	...	...	Not seen	Not seen
	2.18½ ,,	...	289				
	2.19 ,,	...	...				
	2.19½ ,,	...	...				
	2.20 ,,	...	276				
	2.20½ ,,	...	277 30				
	2.21 ,,	...	279				
	2.21½ ,,	...	280				
	2.22 ,,	...	280 30				
	2.22½ ,,	...	281				
	2.23 ,,	...	281 30				
	2.23½ ,,	...	281 45				
,, 8	No. 4, 9.24 a.m.	...	26	7 30	...	Not seen	Not seen
	9.25 ,,	...	1	23 30			
	9.26 ,,	...	334	40			
	9.27 ,,	...	327	45			
	9.28 ,,	...	299	50			
,, 8	No. 5, 2.24 p.m.	...	211	26	...	313° ′	33° ′
	2.24½ ,,	...	245	37	...	296	38 30
	2.25 ,,	...	251	35 30	...	284 30	38 30
	2.25½ ,,	...	254 30	31 30	...	279	38 30
	2.26 ,,	...	253	30	...	273	37 30
	2.26½ ,,	...	252	29 30	...	265	37 30
	2.27 ,,	...	251 30	29 30	...	259	38 30
	2.27½ ,,	2.29¼ p.m.	251	29	...	252	38 30

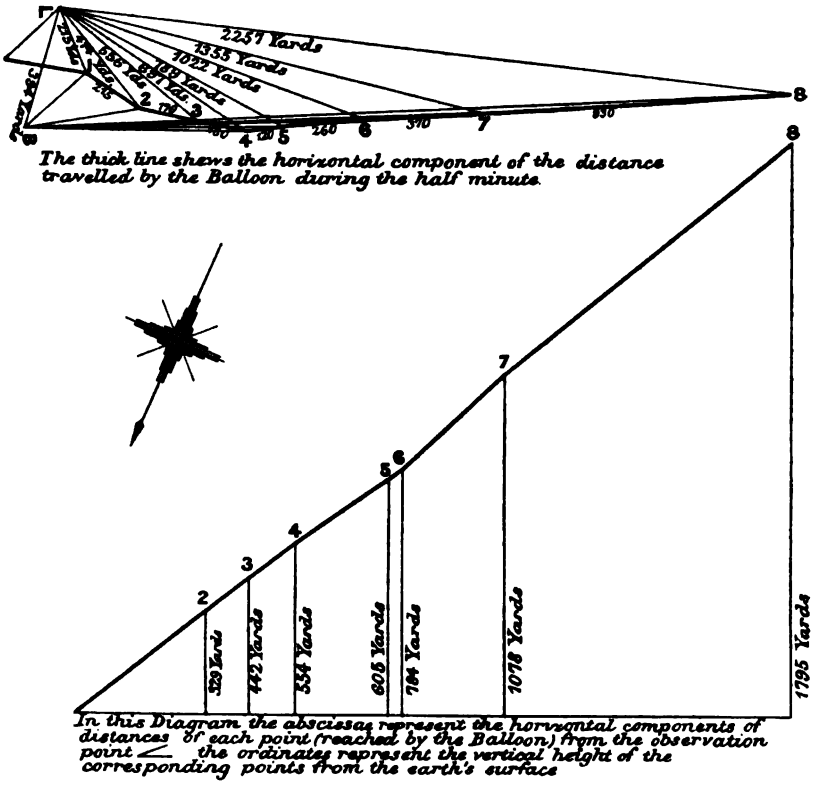
On the first day neither theodolite, and on the second day, morning and afternoon, and on the third day in the morning, only one of the theodolites succeeded in obtaining observations. Difficulties of light and clouds, and the small size of the balloons for the distances employed, prevented the other theodolite from either seeing or following continuously the flight. For the last ascent it was decided to greatly diminish the distance of the stations from each other, and to let off the

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balloon at a point midway between and nearly on a line joining the observation stations.



On this occasion a complete double set of records was taken, and the results have been worked out by Messrs. Lingwood and Bowen, and their drawings are given in the accompanying figure.



They show that—

At a height of	The horizontal component of the wind's velocity was approximately
329 yards	430 yards per minute.
442 ,,	340 ,, ,,
554 ,,	320 ,, ,,
605 ,,	240 ,, ,,
784 ,,	520 ,, ,,
1078 ,,	740 ,, ,,
1795 ,,	1860 ,, ,,

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TABLE II.—Meteorological Observations taken at Codrington House, St. Michael, Barbados, on November 6, 7, and 8, 1907, the Days on which Balloon Experiments to ascertain the Upper Currents of the Air were carried on. Height above Sea-Level, 181 Feet.

Date and Time.	Barometric Pressure.	Attached Thermometer.	Thermometers.					Wind.		Clouds.		Total Amount.	Initial of Weather.	Remarks.
			Dry Bulb.	Wet Bulb.	Maximum.	Minimum.	Solar.	Direction.	Velocity.	Lower.	Upper.			
	ins.	°	°	°	°	°	°							
Nov. 6 at 8.0 a.m.	29·901	82·8	82·0	77·8	84·9	74·0	124·0	E.	7·0	Cum. Fr. cum.	Cirrus Cir. str.	5	C	Velocity—Mean of 24 hours, 8 a.m. 5th to 8 a.m. 6th.
8.30 ,,	...	...	...	...	...	...	...	E.	11·7	...	...	...	...	,, From 7.30 a.m. to 8.30 a.m. 6th.
9.0 ,,	29·915	83·6	83·6	77·2	84·9	74·0	124·6	E.S.	10·2	Cum. Fr. cum.	Cirrus	5	C	,, ,, 8 a.m. to 9 a.m. 6th.
2.0 p.m.	...	...	...	...	...	...	...	E.	7·2	...	...	...	...	,, Mean of 5 hours, 9 a.m. to 2 p.m.
3.0 ,,	29·831	86·0	84·0	77·4	86·7	82·4	138·0	E.S.	11·8	Cum. Fr. cum.	Cirrus	4	B	,, From 2 p.m. to 3 p.m.
Nov. 7 at 8.0 a.m.	29·877	82·6	82·2	77·2	84·7	73·4	119·0	E.N.	6·3	Cum. Fr. cum. Nimb.	Cirrus Cir. str.	6	C	,, Mean of 24 hours, 8 a.m. 6th to 8 a.m. 7th.
8.20 ,,	...	...	...	...	...	...	...	E.N.	14·4	...	...	...	...	,, From 7.30 a.m. to 8.20 a.m. 7th.
9.0 ,,	29·894	83·8	82·6	77·2	84·7	73·4	129·0	E.N.	16·5	Fr. cum. Cum. nimb.	Cir. str. Cir. cu.	8	C	,, ,, 8 a.m. to 9 a.m. 7th.
2.0 p.m.	...	...	...	...	...	...	...	E.N.	11·4	...	...	...	...	,, Mean of 5 hours, 9 a.m. to 2 p.m.
3.0 ,,	29·815	85·2	83·6	76·8	86·1	81·6	136·0	E.N.	8·1	Cum. Fr. cum.	Cir. str.	3	B	,, From 2 p.m. to 3 p.m.
Nov. 8 at 8.0 a.m.	29·895	81·6	81·2	75·6	84·5	68·6	121·0	E.	5·8	Cum. Fr. cum.	...	4	B	,, Mean of 24 hours, 8 a.m. 7th to 8 a.m. 8th.
8.30 ,,	...	...	...	...	...	...	...	E.	8·0	...	...	...	...	,, From 7.30 a.m. to 8.30 a.m. 8th.
9.0 ,,	29·912	83·0	82·0	75·8	84·5	68·6	122·0	E.	8·2	Cum. Fr. cum.	Cirrus	5	C	,, ,, 8 a.m. to 9 a.m. 8th.
2.0 p.m.	...	...	...	...	...	...	...	E.	5·7	...	...	...	...	,, Mean of 5 hours, 9 a.m. to 2 p.m.
3.0 ,,	29·835	84·8	82·6	76·6	85·9	82·0	135 2	E.	8·5	Cum. Fr. cum. Cum. nimb.	Cirrus	4	B	,, From 2 p.m. to 3 p.m.

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The direction of the wind was approximately East of North-east.

It is noted that the rate of ascent of the balloon was much greater at higher elevations than near the earth.

Mr. J. R. Bovell's record of the meteorological observations at Codrington on the dates of the experiments are given in Table II.

To each balloon a linen label was attached written in English, French, and Spanish, asking for the return of the label with particulars of when and where found; but none have so far been received.

DISCUSSION.

Mr. C. J. P. CAVE said that he believed the reason the balloons were lost on these occasions was because they were sent up to windward and came over the heads of the observers. He understood that more hydrogen was to be sent out, and hoped that further observations would be made. It was an interesting locality, and he was glad that the Society was able to arrange for further observations.

Lightning and Compasses.

On 15th June last, in the vicinity of Rottnest Island, the P. and O. steamship *Britannia* (Capt. S. Barcham) was under the influence of a Westerly gale. The squalls were fierce, and the flashes of lightning seemed to be very close, although there was not any thunder heard. In the special meteorological log-book kept by Captain Barcham for the Meteorological Office, and also in a letter, he calls attention to the peculiar nature of the lightning experienced. The flash resembled that of a rocket bursting, and was at first supposed to be due to a rocket night-signal from the lighthouse. Immediately after the first flash the steering and the standard compasses (Lord Kelvin type) commenced to oscillate 45 degrees each way. The compasses were similarly affected on the occasion of each flash, but the needles came to rest between the successive flashes. There appeared a short note on the back of the *Meteorological Chart of the North Atlantic and Mediterranean* for June, which gave several instances of ships struck by lightning, on one of which occasions the compasses of the P. and O. steamship *Victoria* were affected. [This note is supplementary to that of the June issue on ships struck by lightning.[1]]—*Monthly Meteorological Charts of the North Atlantic and Mediterranean*, September 1908.

Australian Commonwealth Bureau of Meteorology, Melbourne.

This Bureau, which has recently been inaugurated by the Commonwealth Government at Melbourne, and is under the direction of Mr. H. A. Hunt, late of the Sydney Observatory, has got to work. Mr. Hunt not only issues the Daily Weather Chart of Australasia, which was commenced on January 1, 1908, and is the first example of one office issuing a daily map which gives the weather conditions for a whole continent, but he has also commenced the publication of a series of *Bulletins*, of which the first two are to hand. No. 1 deals with "The Climate and Meteorology of Australia," and No. 2, "The Rainfall Map of the Commonwealth of Australia."

Rainfall Map of Australia.

The Commonwealth Bureau of Meteorology has published a Rainfall Map of Australia, which has been compiled from observations taken during the

[1] See *Quarterly Journal*, p. 188.

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decade ending 1906. This period has been adopted to enable an equitable comparison to be made with the records taken in the inland district of Western Australia, and in other parts of the interior where the figures are only available for a period not longer than ten years.

The records from nearly 700 stations have been used in the compilation of the map. The period dealt with has been an unusually dry one, especially over the northern and eastern parts, so that the averages given on the map in the earlier settled parts of the continent are much below what may be considered an approximation to the true means. In the letterpress which accompanies the map a table is given, showing the average for all the years available, together with the ten years' average for 168 stations which have averages varying from 67 years downwards. A casual glance at the map shows that the heaviest rainfall is over the northern and eastern parts of the continent; but while this is so, the most reliable, although lighter rains, are experienced over the south-western and south-eastern portions, including Tasmania. The driest part of Australia—that which receives a rainfall of 10 ins. and under—comprises an area which equals nearly one-third of the Commonwealth, and includes the central territory of South Australia, the extreme western parts of New South Wales, the south-western parts of Queensland, and the south-west, central, and part of the north-west portion of Western Australia. One million and eighty thousand square miles of the country, or over one-third of the continent, receives an average of from 10 to 20 ins.; and the remaining third enjoys abundant rain, ranging from 20 to 130 ins. per annum. The wettest part of the Commonwealth is situated about the Johnston River, on the north-east coast of Queensland, and on the west coast of Tasmania. The highest annual average recorded is 130 ins. at Geraldton, in the first-named state, and 114 ins. at Queenstown, in the second-named state. Sixty inches and over are annually recorded from several portions of the Queensland and New South Wales coasts, and also on the Southern Alps, on the border of New South Wales and Victoria. The smallest average annual rainfall in the Commonwealth is 3·8 ins., which occurred over a comparatively small area of country in the centre of the continent to the north of Lake Eyre.

International Geographical Congress at Geneva.

The Ninth International Geographical Congress was held at Geneva from July 27 to August 9. One of the Sections was devoted to Meteorology, Climatology, and Terrestrial Magnetism, the President of this section being Prof. Hellmann, of Berlin, and the Secretary, Dr. Alfred de Quervain, Zürich. Various Reports were presented to the Section, and M. Maurer, the Director of the Central Meteorological Institute of Zürich, exhibited a new Rainfall Map of Switzerland, which completed that of the late M. Bilwiller published in 1893. A report was also presented on the work published by the Geographical Society of Portugal, entitled "Elements of Nautical Meteorology." Prof. Hellmann described a new method of determining the average rainfall of a district, and Dr. Polis of Aix-la-Chapelle spoke of weather-forecasting and the use of wireless telegrams. Prof. Kassner described the uses of his Meteorological Globes, and Prof. Gautier read a paper on the climatology of the Grand St. Bernard.

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OBSERVATIONS ON THE COLOUR OF LIGHTNING MADE AT EPSOM, 1903 TO 1907.

By SPENCER C. RUSSELL, F.R.Met.Soc.

[Read May 20, 1908.]

In the year 1903 I commenced a series of observations on the colour of lightning, and as these observations have now extended over a period of five years, I propose to lay the results before the Society. The great majority of the records have been made from Epsom Downs (450 feet above sea-level), where a practically clear horizon is obtainable in every direction, and the site is a very favourable one for viewing the reflection of lightning occasioned by storms in the Channel or neighbourhood of the coast. There is also a complete absence of artificial light, which is a *sine qua non* for carrying out observations on which a question of colour depends. My method of observation has been to keep a record of the colour or series of colours noted during each thunderstorm or display of sheet lightning, as the case may be, and to tabulate them under their respective colour, month, and year. The tables do not show the relative frequency of any particular colour or colours, only that particular colours or a single colour were noted during a storm or display of sheet lightning. My original intention was to endeavour to keep a record of the relative frequency of a particular colour, but very short experience showed me that it would be impossible to deal with every observation on such a footing. The term "fork lightning" must be understood as referring to observations of the direct flashes occurring during a thunderstorm, whilst that of "sheet lightning" includes either observations of light flashes taking place in the neighbourhood of the horizon, the reflection of lightning at a considerable distance, or the illumination of a cloud or clouds by a glow discharge, the direct flash being invisible.

After some consideration it was decided to tabulate the records into eight divisions of colour, those selected being red, blue, violet, orange, golden, yellow, white, and green. Even under this limited nomenclature considerable difficulty was experienced at times, more especially when dealing with those storms occurring during the daylight hours, in distinguishing between blue and violet, and golden and yellow, the general tendency of these pairs of colours being to grade into one another almost imperceptibly. Dealing with the results obtained of fork lightning, during fifty-seven storms (Table I.), these resolve themselves into fifteen sets of observations.

Red alone occurred nine times during the period, followed by red and blue eight, and blue alone seven. Red and blue in combination with other colours occurred fourteen times, whilst red combined with colours other than blue was seen six, and blue in combination with colours other than red once. White and yellow were also observed alone on two occasions respectively, all the others occurring in combination. The greatest number of colours seen during a single storm amounted to seven, these being red, blue, violet, orange, yellow, white, and green, taking place on three occasions.

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Cyclonic thunderstorms of the winter months are accompanied by lightning either red or blue in colour, or in combination.

TABLE I.—Combination of Colours (Fork and Sheet Lightning) and Number of Times observed during 1903-07.

Fork Lightning.

Red.	Blue.	Violet.	Orange.	Golden.	Yellow.	White.	Green.	1903.	1904.	1905.	1906.	1907.	Total.
R	...	...	...	...	...	...	...	4	2	1	1	1	9
R	B	...	...	...	...	...	...	1	1	1	2	3	8
...	B	...	...	...	...	...	...	1	2	1	2	1	7
...	...	...	...	G	...	W	...	2	2	1	...	1	6
R	...	...	...	G	Y	...	...	4	...	1	...	1	6
R	B	V	O	...	Y	W	Gr	...	...	...	2	1	3
R	B	V	O	G	...	W	...	...	...	1	1	1	3
R	B	V	...	G	...	W	...	2	...	...	...	1	3
R	B	V	...	G	Y	W	...	...	1	...	...	1	2
R	B	...	...	...	...	W	...	2	...	...	...	...	2
...	...	V	...	...	...	W	...	...	1	1	...	...	2
...	...	...	...	...	...	W	...	...	1	1	...	...	2
...	...	...	...	...	Y	...	...	...	...	1	...	1	2
...	B	V	...	G	Y	W	Gr	...	...	...	...	1	1
K	B	...	O	...	...	W	...	...	...	...	1	...	1
Total								16	10	9	9	13	57

Sheet Lightning.

Red.	Blue.	Violet.	Orange.	Golden.	Yellow.	White.	Green.	1903.	1904.	1905.	1906.	1907.	Total.
R	...	...	...	...	...	...	...	...	2	2	3	2	9
...	...	...	...	...	Y	...	...	1	1	...	2	5	9
...	...	...	...	...	...	W	...	2	1	1	1	4	9
R	...	...	...	G	...	...	...	1	...	1	...	5	7
...	...	V	...	...	...	...	...	1	...	2	1	3	7
...	...	...	...	...	Y	W	...	3	1	1	1	...	6
...	...	...	...	G	...	...	...	...	1	...	1	4	6
...	B	...	...	...	...	W	...	1	2	...	1	1	5
...	B	...	...	...	...	...	...	...	1	1	1	2	5
...	...	...	O	...	...	...	...	1	...	...	1	3	5
...	...	...	...	...	...	W	Gr	1	...	...	...	2	3
...	B	V	...	...	...	W	...	...	...	...	2	...	2
...	...	...	...	G	Y	...	Gr	...	...	...	1	1	2
R	B	...	...	...	...	...	Gr	...	...	...	...	1	1
...	B	V	...	...	...	...	Gr	...	...	...	...	1	1
...	...	V	O	...	...	W	...	...	...	...	...	1	1
Total								11	9	8	15	35	78

The observations of sheet lightning, amounting to seventy-eight (Table I.), divide themselves into sixteen sets of observations, red, yellow, and white alone being seen nine times each, violet seven, golden six, and blue and orange five. In sheet lightning green was the only colour that was not observed alone; the remainder of the observations, as

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will appear from the table, were made up of colours in combination. The maximum combination of sheet lightning colours has not exceeded three.

The greatest contrast arising from a comparison of the two portions of the table is the frequency of sheet lightning to be of a single colour: out of the eight colours seven occurred separately, whereas in fork lightning only four colours were noticed as occurring singly. The marked predominance of red and blue, as disclosed by the observations of fork lightning, is not borne out in anything like the same degree in sheet lightning, the tendency of the latter being for a more equal distribution of colour.

In the severe thunderstorm of May 31, 1903, the commencement, and, in fact, the greater part of the storm was marked by a predominance of red, blue, and violet colours, which, as the storm progressed towards its end, tended to fade away into golden and white.

The thunderstorm of April 13, 1904, occurred during the hours of darkness, and was therefore favourable for observations; the colours during the latter part of the storm again faded away to golden, yellow, and white.

A very severe thunderstorm occurred in the neighbourhood of the Thames Valley on May 8, 1906. As seen from Epsom it was situated to the westward. The storm was of considerable duration with a brilliant display of lightning, no less than seven colours being noted. It may be described as a white and yellow storm, these two colours being the markedly prevalent ones, the distribution of red, blue, and violet occurring during the middle period of the storm.

The Guildford storm of August 2, 1906, was a distinctly blue and red one during the greater part of its continuance. The storm occurred at a considerable height, and to that fact, and to the prevalence of moonlight during the greater portion of the storm exercising an influence on the lighter colours, I attribute the excessive frequency of blue and red. During the latter part of the storm there was again a fading away to golden and white. It is somewhat difficult to generalise on the results obtained from these four storms, but the tendency is for the beginning and middle period to be associated with the more brilliant colours, while towards the end there is a fading away, and change both of colour and intensity. This may be in a great measure attributable to the increasing distance of the lightning.

A summary of the relative frequency of colour during the four storms as given in Table II. discloses the fact that the colours follow exactly the same order as those of fork lightning as deduced from the yearly tables. I believe that this is only a coincidence which would probably disappear if more individual storms had been treated with regard to relative frequency of colour.

TABLE II.—Colour of Fork Lightning in Order of Relative Frequency as Deduced from Observations of the Thunderstorms on May 31, 1903; April 13, 1904; May 8, 1906; and August 2, 1906.

Red.	Blue.	White.	Golden.	Violet.	Yellow.	Orange.	Green.
110	100	91	71	63	57	26	12

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Cause of the Colour of Lightning.—The various colours which lightning affects appear to depend upon the following circumstances:—(1) The height of the storm; (2) The electrical energy; (3) The density of the air; (4) The moisture of the air; (5) Substances suspended in the air; and (6) The distance of the flash from the place of observation.

The green flashes, although of very infrequent occurrence, apparently take place at the greatest height, being followed by blue and violet, as these three colours are frequently noticed playing over and above the others.

It would seem that the presence of hail, when occurring in association with a thunderstorm, is intimately connected with blue lightning. I have tabulated the storms during which hail occurred during the five years, together with the colour of the lightning seen (Table III.), from which it will be noticed that on five occasions red and blue in combination occurred alone, blue on three alone, and varying colours on two, of which on one red and blue, and on the other blue, entered into the composition.

TABLE III.—Thunderstorms accompanied by Hail, 1903 to 1907.

Date.	Red.	Blue.	Violet.	Orange.	Golden.	Yellow.	White.	Green.
May 30, 1903 .	R	B	...	...	...	...	...	...
March 29, 1904 .	R	B	...	...	...	...	...	...
,, 30, 1904 .	...	B	...	...	...	...	...	...
,, 15, 1905 .	...	B	...	...	...	...	...	...
January 9, 1906 .	R	B	...	...	...	...	...	...
February 8, 1906	R	B	...	...	...	...	...	...
April 22, 1906 .	...	B	...	...	...	...	...	...
August 2, 1906 .	R	B	V	O	G	...	W	...
,, 6, 1907 .	...	B	V	...	G	Y	W	Gr
,, 11, 1907 .	R	B	...	...	...	...	...	...

Rain has considerable influence on the colours: before its commencement the brightness of the colours is much intensified; falling rain causes considerable diminution of colour, and even after cessation the colours do not brighten up in any marked degree. A partially cloudy sky is very much better for gathering the variability of colour than a completely overcast one. Artificial illumination exercises in a marked degree an effect on colour. Observations made under these circumstances show that red and orange are to all intents and purposes incapable of separation, the latter colour grading into the former, whilst the distinction of golden and yellow is impossible; at the same time it does not appear to exercise any effect on the distinction of blue and violet, this latter being in exact opposition to that experienced during the daylight hours.

During warm weather showers at night are often accompanied by a form of sheet lightning occurring above the shower cloud. I have frequently traced these showers with lightning from south-west to north-east; the light displayed is very feeble, amounting at times to little more than a glimmer, the colour varying from silvery grey to straw. To avoid duplication these colours have been entered as white and yellow respectively. I mention this observation as showing in some small degree the difficulty that arises at times as to under what description a colour shall

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be entered. The observations I have obtained on the variation of colour, with the distance of the flash from the place of observation, point to the fact that distant storms are accompanied by lightning the prevailing colour of which is of a light hue.

On many occasions an apparent connection was noted to exist between the colour of the lightning and the subsequent thunder. Red is followed by thunder of a long rolling nature; blue by thunder in peals, varying both in intensity and duration of sound; white by thunder as nearly as possible resembling the rapid discharge of ordnance; whilst violet and green are followed by the most intense discharge of all.

TABLE IV.—Colour of Fork Lightning in Order of Occurrence.

Red.	Blue.	White.	Golden.	Violet.	Yellow.	Orange.	Green.
37	30	25	21	14	14	7	4

The observations of fork lightning (Table IV.) show red to be of the most frequent occurrence, followed closely by blue; the colours thence descend in fairly regular order to orange and green. White is of the greatest frequence in sheet lightning (Table V.), red and yellow being equal. Blue descends to a somewhat low place on the list, being fifth as compared with fork lightning; orange and green change places.

TABLE V.—Colour of Sheet Lightning in Order of Occurrence.

White.	Red.	Yellow.	Golden.	Blue.	Violet.	Green.	Orange.
26	17	17	15	14	11	7	6

A combination of the two sets of observations still leaves red at the head of the list (Table VI.), followed very closely by white, and blue third in order. Golden appears fourth in all three tables.

TABLE VI.—Colour of Fork and Sheet Lightning Combined in Order of Occurrence.

Red.	White.	Blue.	Golden.	Yellow.	Violet.	Orange.	Green.
54	51	44	36	31	25	13	11

DISCUSSION.

Mr. J. A. Curtis asked if any particular method was adopted for determining the colour of the lightning. He wished to congratulate Mr. Russell upon his energy and perseverance in taking the observations.

Mr. W. W. Bryant enquired what effect, if any, Mr. Russell had noticed due to the frequency of the discharge. One would expect for physiological reasons that with two flashes occurring at a very short interval, the second would be of the complementary colour to that of the other. Storms with frequent flashes would in this way tend to come under Mr. Russell's red and blue class of lightning.

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Mr. W. MARRIOTT said that the subject of lightning was a very fascinating one. In 1888 the late Mr. Symons read a paper on the "Results of an Investigation of the Phenomena of English Thunderstorms," which he had carried out during the years 1857-59. It was one of his earliest papers, and he had begun by collecting observations of thunderstorms and discussing the frequency, the damage done, and the colour of the lightning. The following extract gave a very interesting summary of the results with regard to the colour of lightning:—

"I may perhaps, before stating the results obtained, explain that I have been obliged either to reject or reduce to some of the primary colours the terms employed by some of the observers, such as 'like sulphur flame,' 'like a burning rope,' 'mauve,' etc. On separating the records into the two classes of sheet and forked lightning, I find that, in sheet lightning the most prevalent colour is white, then yellow, blue, and red; in forked lightning, however, the order is nearly reversed, blue being more than twice as frequent as any other colour, then red, white, and most rarely yellow. Blue (or violet) is by far the most frequently recorded colour. In every case but two where I have received communications from persons who have been themselves, or whose houses have been, struck by lightning, and the colour has been mentioned, it has been stated to be blue or violet. The exceptions were red at Ryther School, and yellowish-white with a tinge of blue at Wibsey, near Bradford. Sheet lightning is seen about twice as often as forked."

Mr. Marriott said that the Society took up the investigation of thunderstorms in the years 1888-1889, and one of the questions on the form for the observers to fill up was that of the colour of the lightnings. He had not time to go into all the phases of thunderstorms, and had not been able to take up the question. However, should any one wish to continue the subject, there was much interesting information available, which might be of assistance.

Colonel H. E. RAWSON said that considering the subject from a purely scientific point of view, perhaps Mr. Russell would like to know of a very curious incident during a thunderstorm in South Africa. There was such a charged electrical atmosphere, that though the storm was only visible on the horizon, the covering of the electric wires in his house had become a conductor, that is to say, the insulation round the wires became a conductor, and the current from the town circuit sparked across from one wire to the other, causing the fall of a pendant. The insulation was the ordinary silk covering. Probably such a condition of the atmosphere affects the colour of a flash, just as moisture in the lower levels affects the colours at sunset. The above incident was not an uncommon one during a distant thunderstorm, and he had investigated another case which could only be explained in the same way.

THE PRESIDENT, Dr. H. R. MILL, said the paper was interesting in showing the results of observations made without the use of instruments. His own attitude was more inclined towards questioning rather than commenting. There was one suggestion, however, he would like to make, and that was that if possible observations of lightning flashes should be made with a spectroscope to show whether the changes in colour were due to the physiological effect referred to by Mr. Bryant, or if they had a real basis. Where a disruptive discharge took place, the substances in the air must necessarily determine the colour of the flash.

Mr. S. C. RUSSELL, in reply, said that as regards Mr. Curtis's enquiry as to colour, this had been settled by his own judgment. Colonel Rawson's description of the phenomena he had witnessed, he (Mr. Russell) would call an instance of electrical energy.

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AN ELEMENTARY EXPLANATION OF CORRELATION: ILLUSTRATED BY RAINFALL AND DEPTH OF WATER IN A WELL.

By R. H. HOOKER, M.A., F.R.Met.Soc., F.S.S.

[Read June 17, 1908.]

I AM desirous in the present paper of calling attention to recent methods of dealing with statistics, and more particularly with the process of correlation, and to illustrate, by working out a special example, what results can be obtained. This paper is therefore to be regarded rather as an explanation of the method than as a rigorous procedure to be followed in every case. The procedure appropriate to each particular problem requires to be carefully considered, and we must in each case try to form a clear idea of exactly *what* we are comparing or correlating, and whether, in fact, correlation will give the answer sought. To do this requires a more intimate acquaintance with the science of statistics than can be condensed into the following few pages. But I want to enable all who read these remarks to appreciate the value of the method, so that they may give credence to facts ascertained by experts, even although they may not themselves follow the whole of their work; and also, perhaps, persuade some to study the subject.[1] This is my own position: I am not enough of a mathematician to do more than work out a few problems; and it occurred to me therefore that, being on the same plane as so many others, I might possibly make myself understood better than would a scientist. I have so often myself, when introduced to a new subject, asked: "What is the good of it?" that I have felt emboldened to attempt to make others understand what is the good of correlation.

For the purpose of the present paper, I propose to regard the *correlation coefficient* as a "measure of the resemblance of two sets of observations," and as a corollary, as a measure of the dependence of one phenomenon upon another.

Consider, for instance, the diagram (Fig. 1) which is of a very common form. In this the measurements made of the rainfall (expressed as differences from the average) during a particular period in successive years are plotted at certain regular intervals, and all the points joined by straight lines; the measurements made of the depth of water in a well, with which we wish to compare the rainfall, are also similarly plotted in such a way that the measurements of the same year fall on the same vertical line.

It is clear that in this example there is considerable resemblance between the two "curves" thus drawn: *i.e.* in many cases a rise in the full line is accompanied by a rise in the dotted line, and a fall in the one is generally accompanied by a fall in the other. If this only occasionally happened, we should say that the coincidence of a rise in both curves was accidental, but in this case the correspondences are so numerous that we say there is evidently a connection between the two curves.

[1] Those who wish to study correlation will find suitable introductions in *Elements of Statistics*, by A. L. Bowley; or "On the Theory of Correlation," by G. U. Yule (*Journal of the Royal Statistical Society*, Dec. 1897).

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The mere enumeration of several coincidences, or their mere exhibition on a diagram, however, is not by any means a satisfactory proof of connection; and what is wanted is a reliable test of whether the coincidences are due to the one phenomenon acting upon the other, or whether they are simply accidental. Such a test is provided by the method of correlation, which will, moreover, give a useful measure of the degree of connection between any two such curves.

Before we can ascertain if the variations of one phenomenon are due to those of another, we must first know what is the ordinary measurement we should expect to find if the second phenomenon were not variable; and we must also know how far the measurements are apt

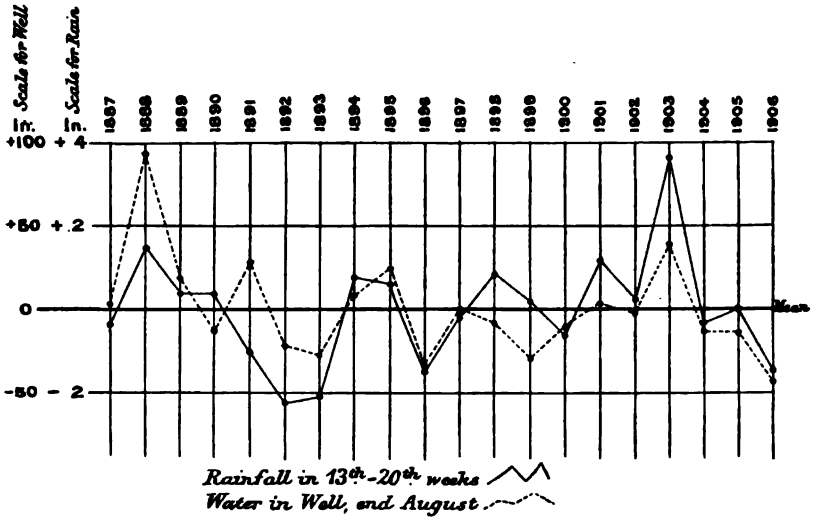


FIG. 1.

to vary naturally from chance causes. The leaves on a particular tree, for instance, are not all of the same size. If we are given several large leaves, we cannot say off-hand that they are due to, say, a heavy rainfall having produced very large leaves on the trees; we must know first what is the size of an ordinary leaf on most trees of the same species, and secondly whether the leaves on an ordinary tree are so variable that the particular size, although large, is still fairly common. When we are satisfied that the leaves are bigger than usual, and also so large as to be out of the common, we suspect a particular cause; but before we are satisfied that a heavy rainfall is that particular cause, we must know whether the rainfall *was* heavy. We must find out also whether it was exceptional, or whether similar rainfalls have occurred before without producing large leaves; in the latter case we should say at once that it was a mere coincidence, and search for some other cause.

Therefore, before we can compare corresponding observations of two particular objects or phenomena, we must have some measure of their ordinary size; and also some measure of their natural variability, *i.e.* of

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their *deviations* from that ordinary size. In the first place, consequently, I must explain two terms, viz. (1) *average*, and (2) *standard deviation*.

The best way of giving people some notion of the size of a number of objects, or measurements, is of course to show them the whole collection. But this is frequently impracticable or inconvenient, and we therefore mention one particular size which will give the best idea we can of the whole collection. Such a representative number may be termed an *average*. The average most commonly used is that obtained by adding together all the measurements, and dividing the total by the number of measurements. We might say, for instance, that the average size of a cherry is half an inch in diameter. By this we do not mean that every cherry is half an inch in diameter; but that, if a large number are taken, half an inch gives a fair idea of most of them, and we can, for example, form a very good notion of the space necessary to store a given quantity. Similarly, if we say that the average rainfall in April at a certain place is 2·5 ins., we do not mean that the rainfall every April will be 2·5 ins., but that during the past fifty years the total rain that has fallen in April was 125 inches.

We must now lay down a formula for the average. Let X_1 stand for one particular measurement of the phenomenon or object, and X_2 X_3, . . . X_n stand for the other measurements, there being n measurements in all. Then, for convenience we may say that X is a variable amount representing any one of the measurements. If, for instance, we are considering April rainfall, X is a symbol which stands for "April rainfall of any year." The formula for the average may be written $\bar{x} = \frac{X_1+X_2+X_3+ \ldots +X_n}{n}$, or more shortly $\bar{x} = \frac{\Sigma X}{n}$, where the Greek capital letter Σ stands for "sum of all the quantities denoted by" X. The quantity $\bar{x}$ is more strictly called the *arithmetic average*, or *arithmetic mean*, frequently abbreviated to "average" or "mean" simply. There are certain other useful representative "averages," among which the following may be mentioned: (1) the median. This is possibly the simplest of all; it is obtained by ranging all the measurements in order, the smallest at one end, and the greatest at the other, and picking out the middle value. If there are $2_n - 1$ measurements, X_1, X_2 . . . X_{2n-1}, the median is X_n; or if there be an even number of observations (2_n) it is $\frac{X_n+X_{n+1}}{2}$. Its chief interest is that there are just as many measurements above as below it, and it may be conveniently quoted in cases where it is desired to know the quantity above or below which values are equally likely to occur.

(2) The *mode* is perhaps the most truly representative average of all, and is the measurement which is likely to occur most frequently: its calculation is, however, difficult. If all the n measurements be arranged in order, it will be found that many values occur frequently; a particular value p, for instance, will occur q times. An arrangement showing how often each value occurs is termed a *frequency distribution*, and a certain value will be found for which q is a maximum; this value will usually be quite near the mode. If the number of observations, instead of being a limited number n, be supposed increased indefinitely, we obtain a *theoretical* frequency distribution, and the most frequent value of this theoretical distribution is called the *mode*. It is in fact the theoretically most frequent value, and not merely the value actually occurring most often

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in the more or less limited number of observations at our disposal. The word is derived from the French "mode" = fashion, and represents the most fashionable value. Various elementary methods of finding an approximation to the mode are given in textbooks.

The different advantages of the three above-mentioned forms of average may be illustrated as follows: If you wish to forecast the total rainfall of the next fifty years, take the arithmetic mean as your standard; if you wish to bet that the rainfall next year will be more or less than a certain amount, take the *median*; if you wish to foretell next year's rainfall, your best chance is to take the *mode*.

It may be noted that if the various measurements are quite evenly distributed in the same way on either side of the arithmetic mean, then mean and median coincide; and except in a few rare cases where extreme values are commoner than intermediate values (*e.g.* proportion of sky clouded), the mode also coincides with them.

Another form of average, commonly used in certain cases, is the *geometric mean*, $g = \sqrt[n]{X_1 X_2 X_3 \ldots X_n}$ or $\log g = \frac{1}{n}\Sigma (\log X)$. This is generally used to calculate increases of population, or for finding "averages" of such phenomena as tend to increase or decrease in a constant ratio.

In what follows, the only average I shall use will be the arithmetic mean, which I shall abbreviate to "mean" simply.

The mean is thus the first thing we require to know concerning the measurements of a group of variable objects. But this gives only a very crude idea of them, and the next most useful piece of information is: How much do individual objects differ from the mean; are some of them very small and others very large, or are they all nearly the same size? We want, in fact, a measure of the way in which they are *scattered* about the mean. Consider the rainfall of April, for instance, at a town where the mean is $2\frac{1}{2}$ inches; we may occasionally—very rarely—find it 0 inches, or again we may quite easily get 5 inches or more, the range being thus at least twice the mean. On the other hand, examine all the ripe cherries from a single tree served in a dish at dessert; their mean diameter is perhaps half an inch, but you will not find any of them over an inch in diameter, nor any of 0 inches; in fact they will all be not far from the half inch; still they are not all of the same size. We should say that the rainfall has a much greater range than the cherries in a dish, and is much more variable.

A measure of this variability is clearly wanted in many cases. A municipality which is laying down a system of drainage does not care twopence about the mean rainfall per day or per hour; this would only be of use if a drainage system could be devised which would store any fall above the mean, and run it off when the rain had ceased falling. On the other hand, it need not provide for an absolute maximum that is liable to occur, say, once in 2000 years. Rather than go to the great expense of preparing for that, it would be cheaper to suffer the damage. A fall of 1 in. in an hour is not unknown in this country, hence 24 ins. in a day is not on the face of it impossible, but a municipality need not provide for the latter. What is wanted is a measure that will give an idea of how often excessive falls are likely to occur.

A simple measure of the variability of a group of measurements is

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obtained by finding the difference between each measurement and the mean, *i.e.* its *deviation* from the average (irrespective of sign), adding all these differences together, and dividing by the number of measurements. This gives the "mean deviation." But a better measure is what is known as the *standard deviation.* This is obtained by adding together the *squares* of the deviations, dividing the total by the number, and extracting the square root of the quotient.

If we call the deviations[1] from the mean x_1, x_2, x_3 . . ., so that $x_1 = X_1 - \bar{x}$, or generally $x = X - \bar{x}$, then the standard deviation, usually denoted by the Greek letter σ, $= \sqrt{\frac{\Sigma x^2}{n}}$.

For most purposes this quantity is the best measure of the variability. Among its practical advantages may be noted the following: — (1) Like the ordinary arithmetic mean, it is constantly of use in further calculations; (2) It will be found that practically half the number of observations differ from the mean by less than two-thirds of the standard deviation.[2] In other words, it is about an even chance that the rainfall next month will not differ from the mean by an amount exceeding two-thirds of the standard deviation. (3) A value differing from the mean by three times the standard deviation only rarely occurs.[2]

It may be noted that the sum of the squares of the deviations from the mean is the least possible; and hence in this sense it may be said that the observations as a group are closer to the mean than to any other value. [The mean deviation is least when the deviations are measured from the *median* and not from the mean.] For, suppose the deviations (y) to be measured from some value other than the mean, and let d be the difference between this other value and the mean ($\bar{x}$), then, for any value X,

$$y = x - d\,;\ y^2 = x^2 - 2xd + d^2.$$

$$\Sigma(y^2) = \Sigma(x^2) - 2\Sigma xd + \Sigma d^2 = \Sigma(x^2) + nd^2$$

(since the sum of the deviations from the mean, by definition, $= 0$, hence $\Sigma xd = 0$), and therefore Σy^2 is least when $nd^2 = 0$, *i.e.*, $d = 0$.

Take, for instance, the full black curve in Fig. 1: this represents the rainfall at Cirencester during the thirteenth to twentieth weeks of each year from 1887 to 1906 (end of March to beginning of May). The horizontal black line—denoted by O—represents the mean rainfall of that period in those twenty years, viz. 3·29 ins. The standard deviation is 1·32 in. I find upon examination of the records that in those twenty periods the rainfall differed from the mean by 0·88 in. or more in eight years only out of the twenty; while the greatest deviation was 3·66 ins., or about $2\frac{2}{3}$ times the standard deviation. Again, the standard deviation of the dotted curve in the diagram (depth of water in the well at a certain date) is 30 ins.; in just ten cases the deviation was less than 20 ins.

[1] As we are going to square these differences, it does not matter whether X is greater or less than $\bar{x}$.

[2] (2) and (3) only hold strictly when the distribution of the measurements about the mean is "normal," or approximately so. If the frequency distribution be plotted on a curve of which the abscissae represent the values, and the ordinates the number of times each value occurs, a "frequency curve" is obtained. If this is of the "cocked-hat" shape, showing a maximum at the centre and tailing off symmetrically at either end, with an equation of the form $y = ae^{-\frac{x^2}{2\sigma^2}}$, the frequency distribution is called *normal.*

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Now we can get on to correlation.

Let us consider again the diagram. We saw that in most cases a big deviation above the mean in one curve is accompanied by a considerable deviation above the mean in the other; while deviations below the mean also commonly come in the same years. Now we all probably know that if we multiply a positive quantity by another positive quantity, the product is positive; and that if we multiply a negative quantity by a negative, the product is also positive; the product being negative only when a positive is multiplied by a negative quantity. Let us call all deviations above the mean, in either of these two curves, positive, and all deviations below the mean, negative. Then if for each of the years we multiply the deviation of one curve from its mean by the deviation of the other from its mean, we see that we have a great many cases where we multiply positive by positive or negative by negative; hence we get many positive products and few negative. Moreover, the biggest deviations of one curve generally correspond to big deviations, on the same side, of the other; hence our positive products are mostly large. If we then add all our products together, we shall have a large positive total. And therefore it is fairly obvious that the more two such curves are alike, the bigger is the positive total.

If we denote deviations from the mean in the full black curve by x, and deviations in the dotted curve by y, then the sum of the products thus obtained is $x_1y_1 + x_2y_2 + x_3y_3 + \ldots + x_ny_n$, there being n values of each of the two variables measured. Or, generally, this may be expressed as $\Sigma(xy)$, *i.e.*, the sum of all quantities like x multiplied by y. So that the more our curves are alike the bigger is $\Sigma(xy)$.

Thus this method gives us the germ of a measurement. But we must know something more: we have a big total, but we do not know *how* near it is to the biggest possible, and therefore how near the two curves are to absolute resemblance. As a matter of fact, the greatest value of this quantity is $n\sigma_x\sigma_y$, and accordingly the *correlation coefficient*, as it is called, is obtained by dividing $\Sigma(xy)$ by n times the product of the standard deviations (σ_x and σ_y) of the two curves, *i.e.*, the correlation coefficient $r = \frac{\Sigma(xy)}{n\sigma_x\sigma_y}$. Now, (1) r always lies between the limits ± 1. (2) If the two curves are so alike that they both rise and fall together, and always in the same proportion, $r = +1$ exactly. (3) If when one goes up the other always goes down, and also always in the same proportion, $r = -1$ exactly. [If we were to correlate any curve with its reflection in still water, r would $= -1$.]

For, $n^2\sigma_x^2\sigma_y^2 - (\Sigma xy)^2 = \Sigma x^2 \Sigma y^2 - (\Sigma xy)^2$, since $\sigma_x = \sqrt{\frac{\Sigma x^2}{n}}$ and $\sigma_y = \sqrt{\frac{\Sigma y^2}{n}}$.

Let $x_1 = \lambda_1 y_1$, $x_2 = \lambda_2 y_2 \ldots$, then $n^2\sigma_x^2\sigma_y^2 - (\Sigma xy)^2 =$

$$(\lambda_1^2 y_1^2 + \lambda_2 y_2^2 + \ldots)(y_1^2 + y_2^2 + \ldots) - (\lambda_1 y_1^2 + \lambda_2 y_2^2 + \ldots)^2$$
$$= y_1^2 y_2^2 (\lambda_1^2 + \lambda_2^2 - 2\lambda_1\lambda_2) + \ldots$$
$$= y_1^2 y_2^2 (\lambda_1 - \lambda_2)^2 + \ldots,$$

which is 0 if $\lambda_1 = \lambda_2 = \lambda_3 \ldots$, but is otherwise positive.

Hence Σxy cannot be greater than $\pm n\sigma_x\sigma_y$, and therefore r lies between ∓ 1. Also, therefore, when $\lambda_1 = \lambda_2 = \lambda_3$, *i.e.* when $x = \lambda y$, $r = +1$ exactly.

If there is no correspondence whatever between the two curves, *i.e.*

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if a big positive deviation in the one is accompanied sometimes by a big positive deviation in the other, sometimes by a negative, and sometimes by no deviation; in fact, if it is pure chance what deviation you get in the second curve with a given deviation in the first, then $r = 0$. Hence the more one curve is dependent upon the other and resembles it, the greater is r, positive if an increase in the one causes an increase in the other (*e.g.* spring rainfall and yield of hay), and negative if an increase in the one causes a decrease in the other (*e.g.* autumn rainfall and subsequent yield of wheat per acre).

It is clear therefore that the correlation coefficient gives us an excellent measure of the resemblance of two sets of observations; and consequently of the dependence of the one upon the other.

Now let us apply the method to a concrete problem. The opinion is usually held that a deficiency of winter rainfall is the cause of scarcity of water in the following summer. *E.g.*, the late Mr. G. J. Symons, in *The Times* of March 31, 1891, said, "I do not diverge into the effect of this drought" [*i.e.* of the preceding winter] "upon the yield of springs and wells during the summer." In two papers read before this Society by my brother, Mr. C. P. Hooker, in 1903 and 1907,[1] this view was emphatically challenged, and he concluded, as the result of his investigations, that plenty or scarcity during summer depended, not on the winter rains, but on the spring rains, more particularly during March and April. We have thus two opposite contentions, the one authority attributing scarcity to a dry winter (October to February or March), the other to a dry spring (March and April). I propose to measure the relationship between the depth of water in a well in summer and (*a*) the winter rainfall, (*b*) the rainfall at various periods in the spring.

The data are all given in my brother's two papers. One point only need be considered here, viz. the date in summer to be chosen. "Scarcity" is probably best measured by the minimum amount of water in the well; but, owing to the different times at which the replenishing autumn rains set in, the date at which this minimum occurs varies enormously. A scarcity in early autumn may often be prevented by heavy rains setting in in September; on the other hand, there may be plenty of water in the well at the end of August, and two months' absence of rain may cause a serious deficiency by November. It is thus desirable to take our well-measurements at a sufficiently early date to eliminate the disturbing factor of the autumn rains. I have accordingly taken the last week in August as the best.[2]

In the first place I shall correlate the well-depth at the end of August with the rainfall of the 13th-20th weeks of the year (this is approximately the period indicated by my brother); and I propose to give the whole work in detail as an example (see Table I.)

A table with several columns must be formed. First write down on the left-hand side the successive years of the period. In the next column write the depth of water in the well at the date chosen (last week in August); add the items, divide by the number of years (20) and we have

[1] *Quarterly Journal of the Royal Meteorological Society*, 1903, **29**, p. 263, and 1907, **33**, p. 287.

[2] Except that in the wet summer of 1891, when a heavy rainfall in the fourth week of August (2·50 ins.) percolated to the well and raised its level by 8 ft., I have taken the measurement of the third week in August.

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the mean depth at the end of August (72 inches). In column 3 write the deviation (x) of the well-depth each year from the mean; *i.e.* subtract each one successively from the mean, and mark it positive if the depth be greater than the mean, negative if it be less.[1] In column 4 write the square of each of the numbers in col. 3; the sum of these squares is n times the square of the standard deviation, $n\sigma_x^2 = 18{,}094$ (whence σ_x can be obtained at once if wanted). Similarly, in the next three columns write (5) the rainfall of the 13th-20th weeks, and calculate its mean, (6) the deviation (y) of each rainfall from its mean, and (7) the squares of these deviations; adding these last we have $n\sigma_y^2 = 34{\cdot}763$. Finally, in col. 8 write the product obtained by multiplying the corresponding deviations given in cols. 3 and 6, being very careful about the sign of the

TABLE I.

Year. 1	Well-depth.			Rainfall.			8
	2 X.	3 x.	4 x^2.	5 Y.	6 y.	7 y^2.	xy.
	Ft. ins.	Ins.		Ins.	Ins.		
1887	6 3	+ 3	9	2·89	−0·40	0·160	− 1·2
1888	13 10	+94	8,836	5·83	+1·54	2·372	+144·7
1889	7 8	+20	400	3·68	+0·39	·152	+ 7·8
1890	4 11	−13	169	3·70	+0·41	·168	− 5·3
1891	8 3	+27	729	2·23	−1·06	1·124	− 28·6
1892	4 2	−22	484	1·07	−2·22	4·928	+ 48·8
1893	3 8	−28	784	1·20	−2·09	4·326	+ 58·5
1894	6 8	+ 8	64	4·07	+0·78	·608	+ 6·1
1895	8 1	+25	625	3·91	+0·62	·384	+ 15·5
1896	3 3	−33	1,089	1·75	−1·54	2·372	+ 50·8
1897	5 11	− 1	1	3·08	−0·21	·044	+ 0·2
1898	5 2	−10	100	4·15	+0·86	·740	− 8·6
1899	3 6	−30	900	3·41	+0·12	·014	− 3·6
1900	5 2	−10	100	2·64	−0·65	·422	+ 6·5
1901	6 3	+ 3	9	4·45	+1·16	1·346	+ 3·5
1902	5 9	− 3	9	3·49	+0·20	·040	− 0·6
1903	9 1	+37	1,369	6·95	+3·66	13·396	+135·4
1904	4 9	−15	225	3·04	−0·25	·063	+ 3·7
1905	4 8	−16	256	3·33	+0·04	·002	− 0·6
1906	2 4	−44	1,936	1·84	−1·45	2·102	+ 63·8
Total	119 4	...	18,094	65·71	...	34·763	+496·8
Average	6 0	...	...	3·29	...	...	...

product. Add up all the positive products (+ 545·3) and from this total subtract the sum of all the negative products (− 48·5): the remainder is + 496·8, which = $\Sigma(xy)$. Divide this by the square root of the product of the totals in cols. 4 and 7, *i.e.* $\sqrt{n\sigma_x^2 \times n\sigma_y^2} = n\sigma_x\sigma_y = 793{\cdot}1$, and the quotient is the correlation coefficient, $r = + 0{\cdot}63$.

This is a tolerably high coefficient, and indicates that there is a distinct connection between the rainfall of the period considered and the depth in the well at the end of August.

We must now consider the probability of this connection being real or accidental. This involves a good deal more mathematics, and depends

[1] In practice, it is more convenient to divide column 3 into two, and put all the positive deviations into one column and all the negative in the other.

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upon that portion of algebra known as the theory of probability. As a result of working on this, it has been ascertained that a very fair test as to the real or apparent dependence of one set of observations upon another is afforded by a factor called the *probable error*.[1] If r be the correlation coefficient and n the number of the observations (20 in the case under review) then its probable error has been found to be $= 0{\cdot}674\frac{1-r^2}{\sqrt{n}}$

It will be observed that this factor depends not only on r (*i.e.* the greater is r the greater is the probability of a real connection), but also on n, and as this is in the denominator, it results that the probable error is greater according as n is smaller. In other words the results obtained from only a few observations are not nearly so trustworthy as those from a large number. This is, of course, only in accordance with common sense.

I do not know whether I can convey any good idea of the principle underlying the notion of the probable error. You doubtless all know that if we toss a coin for a very large number of times, heads and tails will turn up about equally often in the long run. If we toss for a thousand times, however, we shall almost certainly not get *exactly* 500 heads and 500 tails: we should get somewhere near those figures, and we should be very much surprised if we got 600 heads and only 400 tails. So great a difference as a proportion of 3 : 2 is very unlikely to occur, and if it did occur we should suspect very strongly that the tosser was able to exercise some (perhaps small) influence over the coin. Yet if we only toss five times, the nearest approach to equality that we can possibly get is 3 : 2; and if we toss ten times we are almost as likely to get 6 : 4 as 5 : 5. Thus a distinct inequality in the case of a small number of observations is of no significance, whereas it is important in the case of a large number. Similarly a distinct correlation coefficient is no evidence of connection if the number of observations be small, but the same figure is if they be numerous. With a given coefficient, and a knowledge of the number of observations on which it is based, the probability of its being a true connection can always be calculated, and the "probable error" has been found to be the most useful guide. In practice it has been found *absolutely* safe to say that there is certainly a connection between two phenomena if the correlation coefficient be at least six times its probable error. This represents odds of many thousands to one in favour of the connection being real. In the example above, the probable error is 0·09, which is less than $\frac{r}{6}$, and hence we may safely conclude that the rainfall of the period is an important factor in determining the depth of water in the well at the end of August.

Perhaps another example regarding probability may be cited as an illustration. It is well known that the bank at Monte Carlo "always" wins, and that a very steady revenue is derived therefrom. Yet it would seem, to judge by the rules of the play, that the odds in favour of the bank are only very slight. Slight as they appear, however, they tell in the long run, owing to the large number of times the game is played. But still it is not really an absolute certainty; a particular individual may

[1] This term does not mean that the coefficient is probably wrong by the amount of the "probable error," but that in a long series of such coefficients, differences from the mean value greater and less than the probable error are equally likely to occur.

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upon occasion "break the bank," and therefore it is quite conceivable that such an operation may occur so frequently that the bank will have lost by the end of the year. With a correlation coefficient six times its probable error, the chances of there being no connection are far more remote than those of a given individual breaking the bank at Monte Carlo.

Thus, whatever the correlation coefficient (if not unity) there is always a remote chance—it may be many millions to one—that the connection is accidental. But it is always strictly true that the coefficient measures the resemblance that has actually held for the observations included in the calculations. It is only when we want to know whether the connection is causal, and, as a corollary, whether it will still hold in the future, that we have to consider questions of probability. And it may

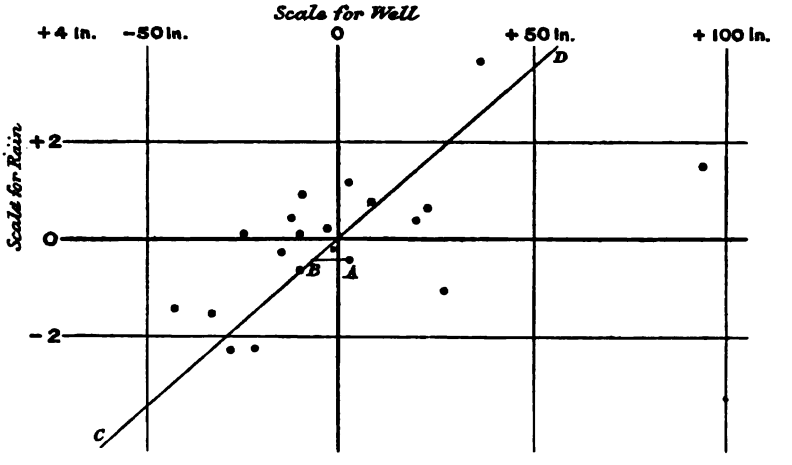


FIG. 2.

perhaps not be amiss to remark that when a writer points out, as frequently occurs, that "inspection of the diagram shows that ups and downs correspond fairly, and therefore the two sets of phenomena are interdependent," such a writer has frequently quite small odds in his favour.

Now let us examine the same set of figures in a different manner. Take some squared paper, and draw a horizontal line, about the middle of the paper, and a vertical line, also about the middle. We have now divided the paper into four compartments. Make a vertical scale on one side to represent deviations of the rainfall from the mean, putting O at the horizontal line, all deviations above the line being positive, and those below negative, and the range being great enough to cover all the deviations in col. 3 of our correlation table. Similarly make a horizontal scale for the well-depth, the central vertical line representing O: we will put positive deviations to the right and negative to the left.[1] The squared paper can now be used to plot corresponding deviations of both rainfall

[1] In the example given here the vertical scale has been made twelve and a half times the horizontal, so as to exhibit the features better.

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and well-depth by means of single dots. Take the first year, 1887, for instance; we have a rainfall 0·4 in. below the average, and a well-depth 3 in. above: I therefore put a dot at a distance 0·4 *below* the horizontal line, and 3 to the *right* of the vertical line. This is the dot marked A. Similarly for all the other years, so that I have a diagram, (Fig. 2) with 20 dots on it.

It will be observed that most of the dots—at least those that are remote from the centre—fall in the upper right-hand compartment, or in the lower left-hand compartment, comparatively few being in the other two compartments; moreover, when a dot is far from one central line, it is not very near to the other. In fact, the dots are not distributed haphazard, but have a tendency to approach a line, or to lie in a belt, running through the centre of the diagram from one corner to the other. I have drawn a straight line (CD) upon the diagram with the following property, viz.: that if we draw horizontals from all the dots to it, then the sum of the squares of all these horizontals is a minimum, that is, the sum of the squares of lengths such as AB is a minimum. Those who have studied analytical geometry know that a line can be expressed by an equation: the equation to CD is $x = \frac{\sigma_x}{\sigma_y} ry$, where σ_x, σ_y and r have the same meaning as before.

For, let the equation to the line CD be $x = \lambda y$, and let $x_1 y_1$ be the ordinate of the point A, thus $AB = x_1 - \lambda y_1$

$$AB^2 = x_1^2 - 2\lambda x_1 y_1 + \lambda^2 y_2^2$$
$$\Sigma(AB^2) = \Sigma x_1^2 - 2\lambda\Sigma(x_1 y_1) + \Sigma(\lambda^2 y_1^2)$$
$$= n\sigma_x^2 - 2n\sigma_x\sigma_y\lambda r + n\lambda^2\sigma_y^2$$
$$= (n\sigma_x^2 - 2\lambda\sigma_x\sigma_y r + \lambda^2\sigma_y^2)$$

To find the minimum value of the expression in brackets, differentiate with regard to λ and equate to 0, then

$$-2\sigma_x\sigma_y r + 2\lambda\sigma_y^2 = 0 \text{ when } \lambda = \frac{\sigma_x}{\sigma_y} r.$$

Hence $\Sigma(AB^2)$ is a minimum when the equation to the line is $x = \frac{\sigma_x}{\sigma_y} ry$.

In this example $x = 14{\cdot}3y$.

Thus what we have been doing in calculating the correlation coefficient really amounts to finding a straight line along which the observations, plotted in this manner, tend to group themselves. And this points a warning: the observations might not tend to approach a straight line, but some other curve; in which event the correlation coefficient is not the best indicator of the connection between the two sets of observations, and to find the true relationship becomes a much more complicated task. It is always as well, therefore, to plot such a "dot-diagram" as the above, in order to see that the relationship is not of a peculiar type. In such a case the correlation coefficient between simple deviations from the average might not show a relationship. The converse, however, does not hold, for if the correlation coefficient is significant, a relationship always exists.

It is evident that a second line can be drawn so as to make the sum of the squares of the *verticals* from the dots to it a minimum: its equation

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is $y = \frac{\sigma_y}{\sigma_x} rx$. The two lines are known as the *regression*[1] *lines*, and the equations may be called the regression equations. They can be made of great practical use—more especially if r be large—since they give the approximate value of y corresponding to a given value of x, *i.e.*, in this instance they enable us to forecast, within certain limits, the depth of water there will be in the well in August from the spring rainfall. It is to be carefully remembered, however, that the forecast will rarely give the exact amount: it only gives an average of the depths corresponding to the given rainfall. In fact, the forecast *is* a kind of average, and it is no more safe to pin our faith to its accuracy in a given year than it is to pin our faith to the rainfall of next June being exactly the average. Inspection of the above "dot-diagram" shows that all the dots lie within a belt running transversely across the paper, and it may be safely forecasted that for a given rainfall the well-depth will lie on that part of the vertical corresponding to the rainfall which is within the belt. For instance, given a rainfall 2 inches above the mean in the 13th-20th weeks, the regression equation forecasts a well-depth of 57 inches above the mean, and it is practically a certainty that it will not be below the mean, and not more than 100 inches above it at the end of August.

It should be noticed that, if we wish to estimate what was the rainfall corresponding to a given depth, we should use the other regression equation. If the one phenomenon depended *absolutely* on the other, then r would, as already stated, be unity, and the two "regression lines" would coincide.

We have found in this case a correlation coefficient of $+0{\cdot}63$. This is not unity, therefore the rainfall of the 13th-20th weeks is not the sole cause of the amount of water in the well. There are other causes, and several of these have been briefly discussed in my brother's papers. Three special cases may be noticed in the second diagram, in two of which the dots are unusually far from the regression line. The farthest of all is 1888. If we refer to the diagrams in my brother's first paper, we shall notice that the heavy rainfall at the end of July and the beginning of August in that year actually succeeded in penetrating to the well and adding 8 ft. of water to it—"a very unusual circumstance." This is an excellent illustration of what I want to bring out, viz., that the method of correlation measures the average dependence during the whole period of the observations. In that *particular* year July-August was certainly the dominant factor, but over the *twenty* years it was not. The 13th-20th weeks were of some importance in that year, but happened to be subordinated to the summer: "a very unusual circumstance." Note that this is fully taken into account in the correlation coefficient: were 1888 omitted, the coefficient would have been different.

The second special year is 1903, in which (otherwise wet) year the very dry July seems to have pulled the well down almost abnormally. But on looking at my first diagram, careful inspection gives rise to the suspicion that there is a tendency for the level of the water in the well to be gradually reduced, *i.e.*, that owing to some cause, possibly more general drainage or other depletion of our underground water supplies,

[1] This term was introduced by Mr. F. Galton in discussing heredity, and is expressive in connection with that science.

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a given rainfall does not result in so much being stored up as twenty years ago. The diagram merely allows us to suspect this, and points to the desirability of confirmative investigation in other directions. If there is a tendency towards a reduction of the average well-depth our regression line should be really not quite a straight line; although for the crude purpose we require, and in view of the small number of years' observations, a result obtained allowing for this factor would differ so slightly from ours as to be negligible.

The third case is the outlying dot in the lower right-hand compartment. This is 1891, when the well was filled in May, having been at a very low level at the beginning of March. This is the year in which, thanks to May, and in some degree also to a wet summer following, Mr. Symons's forecast was so badly thrown out. The winter was the driest of the twenty years, but at the end of the fourth week of August there was actually more water in the well than in any other of the twenty years.

Summing up what has gone before, it may be said that such simple correlation measures the effect of differences from the mean in one phenomenon upon differences from the mean in another, eliminating other factors affecting them; in fact, after making allowances for the causes which pull the dots away from the straight line in the "dot-diagram" above.

The particular problem set can now be solved quite shortly. I have found a connection, indicated by a coefficient of $+0{\cdot}63$, between the well-depth at the end of August and the rainfall of the 13th-20th weeks. What is the coefficient with the winter rainfall? The various winter rainfalls at the same spot—*i.e.*, the rainfalls of October to March—are given in my brother's papers. I correlate them in exactly the same way with the well-depth, and find a coefficient of $-0{\cdot}11$. That is to say, that a heavy winter rainfall tended, if anything, to be followed by a deficiency in the well! But the probable error of so small a coefficient is considerable, viz. $0{\cdot}15$; and it may therefore most certainly be said that the connection is only apparent, and that the depth of the well at the end of August does not depend in any degree whatever upon the winter rainfall. This proves my brother's conclusion that any surplus water which falls in the autumn and early winter has long since reached the sea, and is not available in summer.

If we compare winter rainfall with the well-depth by means of diagrams, we shall find that by plotting the data in the same way as in my first diagram, the ups and downs of the curves by no means correspond. Or if we plot a "dot-diagram," the dots are scattered all over it, and there is no tendency to lie in a belt. A correlation coefficient of practically zero is the mathematical expression of this haphazard distribution.

Correlation also permits of our finding *which* is the most important period, with a little trouble. To do this, it is only necessary to correlate the well-depth successively with different periods. I have done this for the 1st-8th, 5th-12th, 9th-16th, . . . 25th-36th weeks. Of course, the rainfall of the 5th-12th weeks, which overlaps the first period, is partly dependent on it, and therefore if we find a significant coefficient with each period, we cannot say that the well is dependent upon both. Similarly it is quite conceivable that the rainfall of January is connected

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with that of April, and we cannot treat all our correlation coefficients as necessarily independent of each other; *i.e.*, in the latter case a connection with April might be due to the similarity of the January and April rainfalls, and the well might really depend upon January. But it *will* be true to say that the well-depth is most connected with the rainfall of that period with which we get the maximum coefficient; and this I propose to ascertain. The correlation coefficients are as follows:—

Period: Weeks	1st-8th.	5th-12th.	9th-16th.	13th-20th.	17th-24th.	21th-28th.	25th-32nd.
r	−0·28	+0·02	+0·35	+0·63	+0·50	+0·28	+0·42
Probable error	0·14	0·15	0·13	0·09	0·11	0·14	0·12

The maximum is + 0·63, and the 13th-20th weeks (*i.e.*, end of March to middle of May) are therefore the most important of the periods examined. The connection with 9th-16th weeks and with the 17th-24th weeks is obviously due partially to the overlapping of these with the maximum period. It will be noticed, moreover, that all the probable errors, in the case of the other periods, are greater than $\frac{r}{6}$; hence we are not able to say, with absolute certainty, that the well-depth is, normally, dependent upon any of them. Still it is probable that every month after March has, upon a certain few occasions if not regularly, exercised some influence upon the well. I notice that the coefficient of the 17th-24th weeks is greater than that of the 9th-16th weeks, hence I conclude that there is a distinct probability that a period a little later than the 13th-20th weeks—say perhaps the 14th-21st weeks (*i.e.*, April-May)—is the most influential on an average of years. This is even a shade later than my brother puts it. It may possibly be the case that a wet May is only of importance when April has been sufficiently damp to allow the May rains to percolate, and if so it may be said that April was the most critical time even in such years, although its rainfall may have differed but slightly from the average. Such a statement, however, does not seem to lend itself to treatment by the method of correlation, and is neither proved nor disproved by it.

It may be added that by taking periods of a somewhat different duration, says six weeks, or ten weeks, etc., it is possible that we might light upon a somewhat higher coefficient, but the broad statement made above is sufficiently accurate under the circumstances.

DISCUSSION.

THE PRESIDENT thanked Mr. Hooker for his explanation of a very important method of dealing with statistics. In inviting discussion of the paper he wished to remind the Fellows that the object of the paper was the method; and as the facts had already been discussed when the original papers were read, he trusted that the discussion would refer to the method and not to the illustrations.

Dr. W. N. SHAW remarked that the paper brought before the Society for the first time a method which was now applied in many statistical sciences, and had recently been practised by the Director-General of Indian Observatories to measure the correlation between pressures in different parts of the world, and so to form the basis of a numerical statistical method of forecasting seasons in India. It was important that the Society should take account of this method of correla-

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tion. He had spoken of it before the University of London in a lecture, but this had not been published, and he was glad that Mr. Hooker had brought the subject forward again. He did not altogether share Mr. Hooker's opinion as to the extent of its superiority over the diagrammatical method of comparison. It was certainly quite possible to deceive oneself in comparing two curves on a diagram. But on the other hand the correlation method, as described, was applicable only to cases having a linear proportion between the two quantities compared. He would like to know what would happen if one had to deal with a number of observations from two anemometers, one recording the pressure, and the other the velocity. There should be a correlation between them, as the wind force was known to be proportional to the square of the wind velocity. Diagrammatically correlation would be indicated because the elevations on one diagram would be proportional to the square of the elevations on the other. Another point was that, supposing the quantities measured depended upon two independent variables, how would that be represented in the correlation coefficient? He congratulated Mr. Hooker upon his paper, and thought the Fellows should realise the advantages of using this method in their own work.

Mr. R. H. HOOKER, in reply, said that when the relationship between two phenomena was not linear, they had to look very carefully at the results, and also consider very carefully *what* should be correlated. Simple correlation was frequently inapplicable, and higher mathematics might be required to bring out the true connection. On the other hand, various devices could in many cases be employed, *e.g.*, he had himself correlated the oscillations of the marriage rate and trade by correlating, not differences from the mean, but differences from the trend of the curve, *i.e.* from a variable average. He thanked them for the kind way in which they had received the paper.

THE PRESIDENT said that the paper read by Mr. Hooker had been put forward in a very clear and pleasing manner. He hoped that when the paper was printed Mr. Hooker would add an appendix giving the rigid definitions of the terms used, and also of other terms which he had avoided in simplifying his paper, but which ought to be put on record in a form convenient for Fellows of the Society to refer to. He thanked him for his kindness in bringing this important subject before them.

Teaching of Meteorology at Agricultural Institutions.

The President of the Board of Agriculture and Fisheries in the early part of 1907 appointed a Departmental Committee, "to enquire as to the provision which has now been made for affording scientific and technical instruction in agriculture in England and Wales, and to report whether, in view of the practical results which have already been obtained, the existing facilities for the purpose are satisfactory and sufficient, and, if not, in what manner they may with advantage be modified or extended." The Report of this Committee has just been published as a Blue Book. In dealing with the teaching of Meteorology at Agricultural Institutions, the Committee report as follows :—

"The attention of the Committee was drawn to this subject as one which, up to the present time, has received but little attention in this country.

"Dr. H. R. Mill, President of the Royal Meteorological Society, pointed out that the Meteorological Office has amongst its other duties that of preparing reports and weather forecasts for the British Isles, and that he was afraid that a very large number of farmers are not able to profit by this expenditure of public money on their behalf, because of their inability to understand the Weekly Weather Report.

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"Dr. Mill holds that 'imparting a knowledge of the methods of meteorology is technical instruction in agriculture to this extent, that it helps a farmer to decide difficult questions that arise occasionally as to whether he should proceed with a certain agricultural operation in certain conditions of weather, or whether there are sufficient data before him in the published reports, say, of the Meteorological Office, to justify him in postponing it on the ground that better weather is coming.'

"The Committee are of opinion that in agricultural and horticultural institutions, provision might well be made for instruction which would enable farmers and gardeners to make use of existing means of information regarding the weather, and direct farmers' attention to the relations between meteorology and the crops."

Prize Competition of the German Meteorological Society.

Dr. G. Hellmann, the President, has informed us that the German Meteorological Society offers a Prize of three thousand Marks for the best discussion of the meteorological results obtained in the International Kite and Balloon Ascents. The conditions are:—

1. The judges are free to divide the prize.
2. Persons of any nationality may take part in the competition.
3. The communications may be in German, English, or French, and must be well and legibly written on one side of the paper only, and further have a Motto attached. They must be accompanied by a sealed envelope, bearing on the outside the same Motto, and containing inside the name and address of the sender.
4. The latest date for sending in will be December 31, 1911, and communications should be forwarded to Dr. G. Hellmann, Berlin W. 56, Schinkelplatz 6.
5. The results of the competition, as decided by five judges, will be made known in 1912 in the *Meteorologische Zeitschrift*.

Lectures on Meteorology.

Mr. E. Gold will give a course of Lectures in Meteorology at the Cavendish Laboratory, Cambridge, during the Michaelmas term, on Thursdays at 5 p.m., beginning on October 15. The syllabus is as follows:—

Variation of meteorological elements over the surface of the earth. Temperature, pressure, and wind. Comparison with theory. Humidity and rainfall. Cloud and duration of sunshine.

Periodic changes in pressure, temperature, etc. (1) Diurnal, semi-diurnal. Connection between pressure, wind, and temperature variations. (2) Annual. Irregularities in annual temperature curve. (3) Newcomb's investigation of temperature changes of long period. (4) Brückner's 35 year period. Lockyer's Barometric See-saw. Moon-period in thunderstorm frequency.

The relation of pressure gradient to wind velocity. Characteristic difference between cyclonic and anti-cyclonic motion. Motion of the air in cyclonic depressions and line-squalls according to Shaw and Lempfert.

Investigation of the upper air. Results of kite ascents.

The isothermal layer: its bearing on the general circulation.

Correlation. Applications to pressure by Lee and Pearson and Cave-Brown-Cave. Application to rainfall, temperature, and crops by Hooker.

Telegraphic meteorology and forecasting. Abercromby's types of pressure distribution. Guilbert's rules. Ekholms' isallobars.

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THE HONGKONG TYPHOON, SEPTEMBER 18, 1906.

By LAWRENCE GIBBS, F.R.Met.Soc., Assoc.M.Inst.C.E.

[Read June 17, 1908.]

THE typhoons of the China and Eastern seas usually have their origin in the Pacific to the eastward of the Philippine Islands; they occur during every month of the year, but are of rare occurrence during the late winter and early spring.

In point of view of the direction taken, they may be roughly divided into three classes. Those of the first class take westerly or north-westerly courses across the Philippine Islands and the China Sea, and reach the coast of Asia between Saigon and Shanghai. Those of the second class, after first moving westward, "recurve," before reaching the Philippines, and travel to the north and north-east, usually passing up the Japanese Islands. A third class includes those few which follow courses intermediate between, or outside of these.

They have been studied for many years at the Observatories of Manila, Zi-ka-wei (Shanghai), Hongkong, and Tokio, and on the publications of these Observatories most of the information given in this paper is based.

They are found to vary greatly in size, intensity, rate of progress, and direction.

Size.—The typhoons experienced in Hongkong on July 29, 1896, and September 18, 1906, may be taken as extremes in size. During the former a velocity of 108 miles (old constant 3) in an hour was recorded at the Observatory when the centre of the typhoon was 47 miles (nautical) distant; while a mean of several observations at sea gave wind force 6 at 230 miles from the centre. In the latter, force 6 only was experienced at the Gap Rock lighthouse, 32 miles south-west of Hongkong Observatory and 38 miles distant from the centre, and a velocity of 24 miles in an hour was registered in Hongkong 2½ hours before the typhoon centre reached the Colony and when it was only about 30 miles distant. If wind force 6 be taken as the limit, then the 1896 typhoon would be about 500 miles diameter, and the 1906 typhoon less than 100 miles diameter.

Intensity.—The barometric gradient, which is a general, though not an absolute guide to the wind force, often exceeds ·20 inch in 15 miles near the centre of a typhoon; but during the typhoon season shallow depressions are of common occurrence, and these in traversing the China seas often deepen and become regular typhoons. The converse also occurs, a well-defined typhoon sometimes partially "filling up" and becoming a shallow depression. It thus becomes a question of degree what is a typhoon and what is not, and no lower limit other than an arbitrary one can be fixed to the gradient in a typhoon.

Rate of Progress.—This varies mainly with the time of year and the latitude; generally the winter typhoons are slower, and those traversing high latitudes quicker, than the average. The typhoons which cross the Philippines between May and October travel at from

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8 to 12 miles an hour; but in different latitudes and at other times of the year they have been known to travel at from 3 to 30 miles an hour.

Direction.—Fig. 1 shows the tracks of the principal typhoons of 1905 as computed by Mr. F. G. Figg of the Hongkong Observatory.

In view of the considerable area usually covered by a typhoon and their frequent occurrence during the season, there was nothing peculiar in the fact that one should pass close to Hongkong. But the fact which brought the typhoon of September 18, 1906, into such prominence

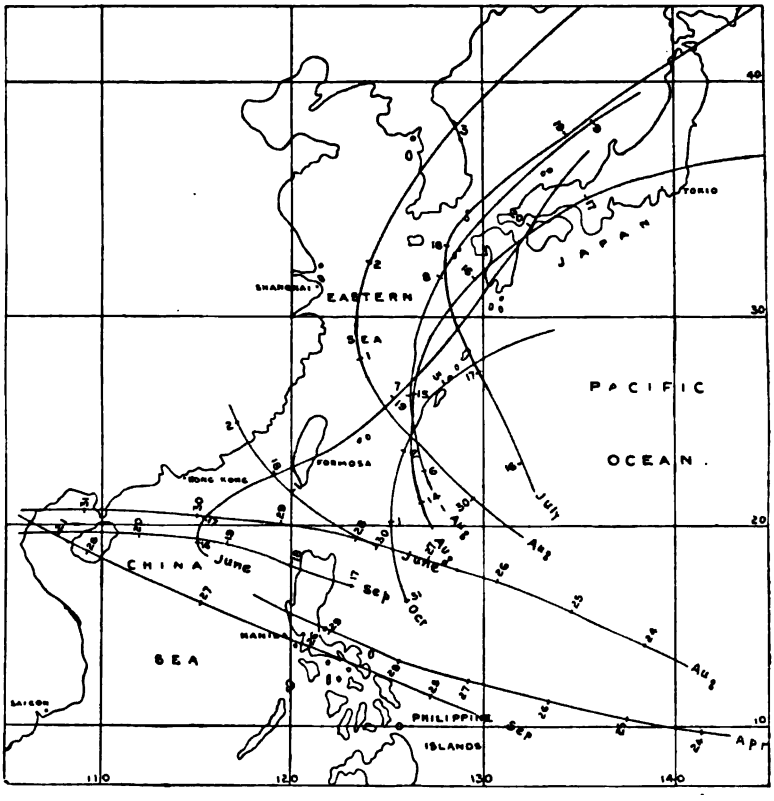


FIG. 1.—Typhoons of 1905.

was the failure of the Observatories to give any adequate warning, and the consequent heavy damage to shipping and small craft. This loss was accentuated by the fact that the typhoon centre passed to the north of the harbour, thus causing a North-westerly backing to Southerly gale. The harbour, as will be seen from Fig. 2, is much less sheltered from the west than from any other quarter.

Judged by anemometer records the typhoon was by no means a severe one. The records are from a Robinson cup anemometer, and the figures available only give the hour's velocity and take no account of the heavy squalls of short duration, which are so distinct a feature in typhoons. Indeed, from the published returns it appears that the highest average

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hourly wind velocity was 77 miles—it never reached what is known as typhoon force or 80 miles per hour. During the 23 years 1884-1906, this velocity has been exceeded on seven separate occasions, totalling 20 hours, at the Hongkong Observatory, the maximum being 108 miles per hour. The small amount of damage done on shore confirms the conclusion thus reached.

In the harbour, 45 merchant vessels of an aggregate tonnage of 46,994 were either badly injured, stranded, or foundered, 80 steam launches out of a total of 256 were permanently or temporarily disabled,

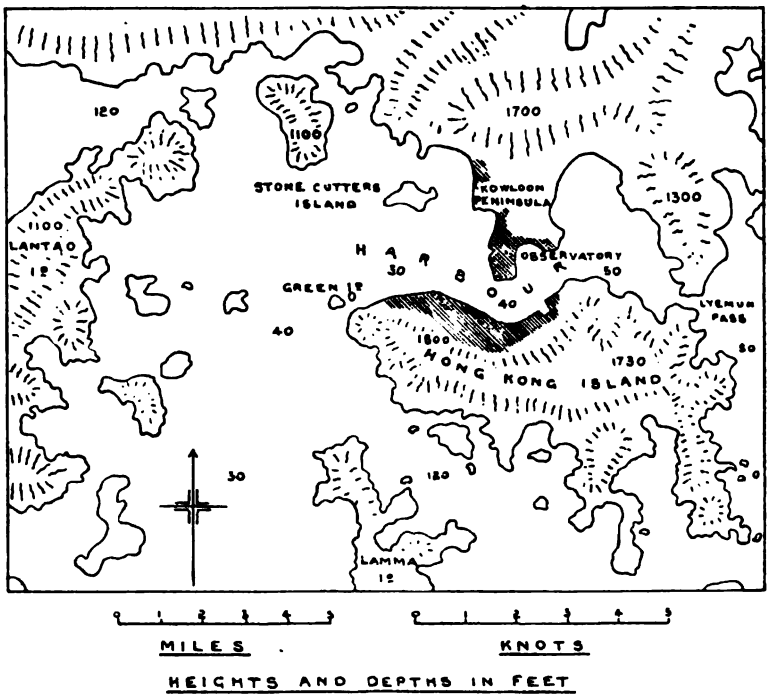


FIG. 2.—Hongkong Harbour.

and a great number of lighters, junks, and small craft broken up. Sixteen Europeans lost their lives, 2385 Chinese were reported missing, but as in many cases the whole family lived on the boat, and as many boats were lost with all hands, it is probable that this figure was considerably exceeded.

The Observatory at Zi-ka-wei came more nearly than any other to an adequate forecast.

It issued the following notices :—

September 15.—"A new centre" (*i.e.* of low pressure) "is signalled advancing towards Formosa from the south of the Meiaco Sima Group."

September 16.—"The centre in the south is nearly stationary at Formosa."

September 17.—"The one reported at Formosa fills up gradually."

September 18.—"A very violent storm of quite limited area raged in Hongkong on Tuesday morning" (*i.e.* September 18).

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The Philippines Weather Bureau issued a Bulletin dated October 10, 1906, in which it gave the probable track (Fig. 3) of the typhoon from 140° east. It was enabled to do this by observations received from vessels at sea in the neighbourhood of the typhoon, and from a report received from the Observatory at Santo Domingo, a station not connected by telegraph with Manila. These observations were considered to

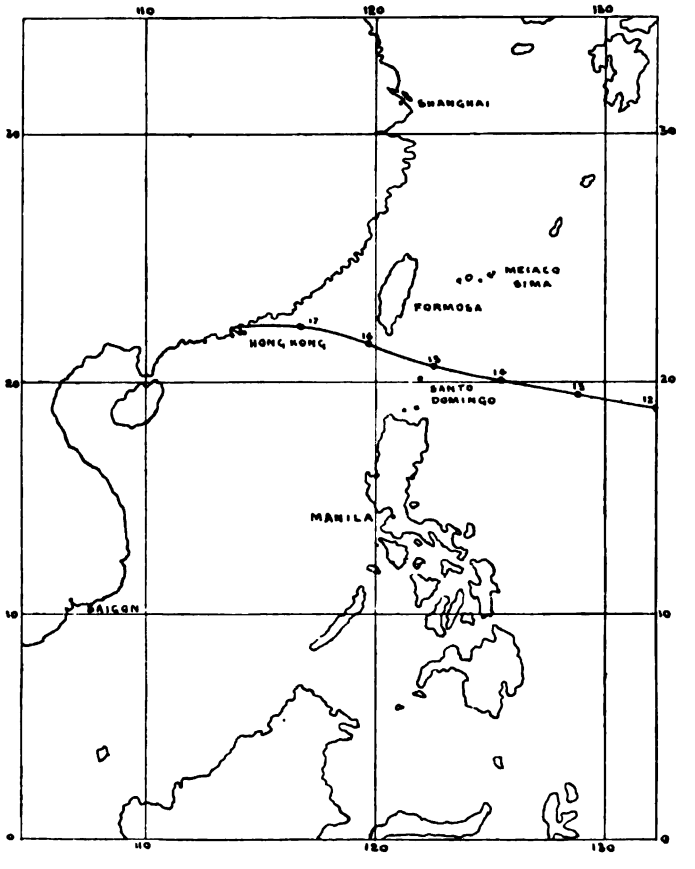


FIG. 3.—Track of Typhoon, September 1906.

corroborate the Zi-ka-wei deductions of the 15th and 16th. As, however, they were only available after September 18, the Manila Observatory was unfortunately not in a position to give any forecast of the typhoon.

The Hongkong Observatory did not consider the observations available on the 16th and 17th justified the issue of any typhoon warnings, and at 11.35 a.m. on the latter date issued the following forecast for the 24 hours ending noon on the 18th:

"Hongkong and neighbourhood.—Variable winds, moderate; probably some thunder showers."

At 8 a.m., however, on the morning of the 18th, it was found that the barometer was falling rapidly, and the weather appearing threatening,

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orders were given to hoist the Black Drum—the weather signal indicating that there was a typhoon within 300 miles to the eastward of the Colony—and at 8.40 a.m. the typhoon gun was fired, indicating that a strong gale of wind was expected to blow. This was only about an hour before the storm was at its worst. It will thus be seen that, though it seems highly probable that Zi-ka-wei located the typhoon fairly closely on September 15 and 16, it did not actually describe it as a typhoon, and lost sight of it after the latter date; and on the 17th, when the storm was advancing directly towards Hongkong, reported it as filling up.

There is no doubt it was the small area covered by this typhoon which caused this failure of the forecasts. This small area is shown in several ways. As has been already stated at the Gap Rock lighthouse, 38 miles from the centre, wind force 6 only was noted. At Macao, 35 miles west, and at Canton, 75 miles north-west of Hongkong, only a slight storm was experienced. Assuming that the rate of travel of two typhoons is about the same, which is approximately the case in the same latitude and season, then the time they take to pass is a fair test of their relative size, if they are equally distant from the observing station. In the typhoon of September 18, 1906, the wind was at 50 miles per hour and over for only 3 hours, with the centre only 6 miles distant. While in the typhoon of October 5, 1894, it blew at over 50 miles per hour for 29 hours; and in the typhoon of July 29, 1896, whose centre passed at 47 miles from the Observatory, 50 miles per hour was registered for 10 hours.

The following table gives the observations of barometer, temperature, rain, and wind at the Hongkong Observatory on September 18, 1906:—

OBSERVATIONS TAKEN AT HONGKONG OBSERVATORY, SEPTEMBER 18, 1906.

Hour.	Barometer.	Temperature.	Rain.	Wind.	
				Direction in points. 32 is north.	Velocity in miles.
	Ins.	°	In.		
1 a.m.	29·685	78·8	...	27	8
2 ,,	·666	79·0	...	25	7
3 ,,	·661	79·0	...	29	10
4 ,,	·636	79·1	...	27	12
5 ,,	·621	78·6	...	29	15
6 ,,	·602	78·4	...	28	14
7 ,,	·584	77·3	·29	27	24
8 ,,	·493	76·8	·13	28	43
9 ,,	·119	74·5	·81	27	73
10 ,,	·066	75·0	1·25	18	77
11 ,,	·493	75·6	·90	16	50
Noon	·590	77·1	·40	18	31
1 p.m.	·645	78·5	·15	15	20
2 ,,	·661	79·4	·05	15	21
3 ,,	·679	80·3	...	14	18
4 ,,	·675	81·9	...	14	15
5 ,,	·681	80·7	...	12	14
6 ,,	·691	79·5	...	9	21
7 ,,	·716	79·5	...	11	21
8 ,,	·755	78·0	·41	11	21
9 ,,	·784	77·7	·17	11	16
10 ,,	·794	79·9	...	9	25
11 ,,	·791	79·5	...	10	22
Midnight	·778	79·8	...	10	28

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Fig. 4 gives the barograms for three typhoons which have passed near to Hongkong, and shows how short the warning given by the barometer was on September 18.

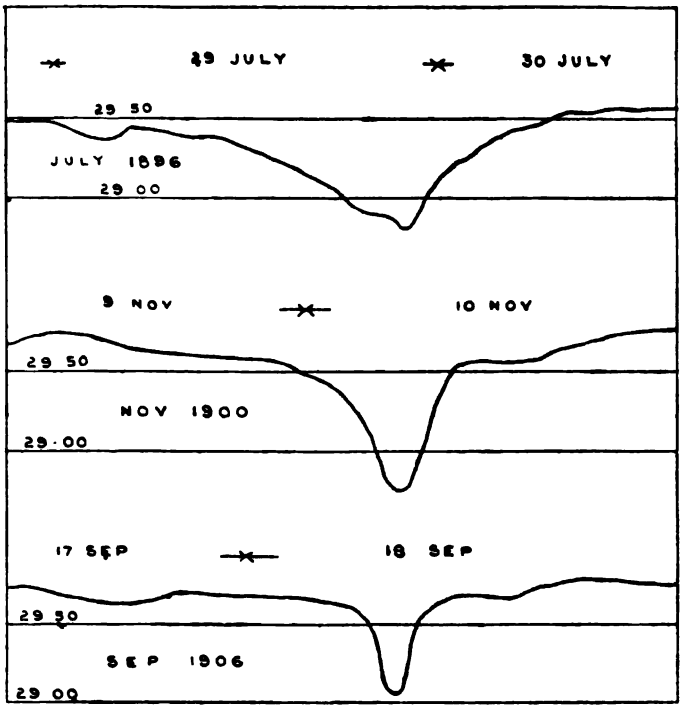


FIG. 4.—Typhoon Barograms in Hongkong.
Plotted from Hourly Readings at Hongkong Observatory.

DISCUSSION

Mr. F. CAMPBELL BAYARD said that with reference to this typhoon, his second son was mate on board the S.S. *Ras Dara*, and he had written him a letter on October 10, 1906, from Ke Lung, Formosa, in which he said :—

"We arrived at Hong-kong last Saturday, October 6, at 8 a.m., and all looking forward for a quiet day the following day. But on our arrival there we learnt of the terrible typhoon that had visited Hong-kong. The Admiralty informed us that we must proceed to Wei-hai-wei, as there was no means of discharging our cargo in Hong-kong, the lighters all having sunk. Well, after taking on board fresh provisions, and the old man doing his business on shore, we hove up the anchor and proceeded, all with sad hearts. As soon as we got outside the harbour the sky was as black as ink, so we thought we should get a typhoon, as four had taken place in the last twelve days. However we didn't, but we *had* a strong North-east gale right up to here. It was so bad that we had to ease our engines for 24 hours. However it can't last much longer now, so we are looking forward now for fine weather."

His son had brought home with him a book with numerous photographs of

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the typhoon effects. It was very interesting, giving pictures of the vessels on shore. In a letter to his mother of the same date, his son had said :—

"We arrived here safely to-day at 1 p.m. for bunkers, but find we can't get any (coal) till to-morrow, so we are having a quiet night anchored in Ke Lung Harbour. We got to Hong-kong last Saturday, October 6, but got orders from the Admiralty to proceed to Wei-hai-wei to discharge. Apparently the typhoon was terrible in Hong-kong, as the report there was that 10,000 lives had been lost. Of course that was not Hong-kong alone. The shipping that was affected was chiefly coasting steamers. A vessel of this size could ride it out all right. During the typhoon we were having light variable winds and calms. Pretty well all the ships in Hong-kong Harbour went ashore, but only one sank, and that was a river steamer."

THE PRESIDENT remarked that this typhoon had been a very serious matter, not only because of the damage it did, but also because it threatened the reputation of the Observatory. The omission of an early warning was indeed considered to be so serious that a Government Commission was appointed to investigate the matter. They took a great deal of evidence, which was carefully discussed, and they finally issued a report entirely exonerating the Observatory.

He thanked the author of the paper, and also Mr. Bayard for reading it and for his remarks. This was the last meeting of the Society for the session. They would meet again in November, he hoped, in the hospitable Hall of the Institution of Civil Engineers.

Cones formed by Melting Snow.

Examples of a peculiar surface form, due in part to the melting of snow, are described from Iceland and the Alps respectively by Herr Spethmann and Professor Brückner in the *Zeitschrift fur Gletscherkunde*, vol. ii. pt. 4. The resemblance of the fields of snow cones, of which photographs are given, to the "nieve penitente" of tropical regions is sufficiently great to suggest a similar origin, though this is not pressed by either of the writers; in fact, Herr Spethmann considers the phenomenon in Iceland to be not entirely analogous with that in the Alps even. The fields which he observed during his recent expedition to Iceland consisted of cones varying in height from half an inch to about 18 ins., and were covered with a layer of volcanic dust, etc., which quite concealed the consolidated snow beneath. They occurred on level or gently sloping ground, and appeared to be in no way dependent on the orientation of the latter. The angle of slope of the individual cones sometimes reached 45°. From the fact that, where not covered with earthy matter, the snow showed few, if any, irregularities, Herr Spethmann concludes that the cone formation is entirely due to the deposition of the dust by the wind and the development on its surface of ripple marks which lead to a differential melting of the snow beneath. Professor Brückner's example is from the Rhone glacier, and shows equally the effect of an original ripple-marking of a layer of dust above the snow.—*Geographical Journal*, September 1908.

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DINNER OF THE ROYAL METEOROLOGICAL SOCIETY.

The Annual Dinner of the Society was held at the Trocodero Restaurant, Piccadilly, on Tuesday evening, June 16, 1908.

The President, Dr. H. R. MILL, was in the chair, and the company included the following Fellows and guests.

Mr. E. B. BARNARD, M.P.
Mr. F. CAMPBELL BAYARD.
Mr. CLAYTON BEADLE.
Mr. A. BOYLE.
Mr. F. J. BRODIE.
Mr. A. H. BROWN.
Mr. ERIC S. BRUCE.
Capt. W. F. CABORNE, C.B.
Mr. C. J. P. CAVE.
Mr. J. E. CLARK.
Capt. M. H. CLARKE.
Capt. R. MUIRHEAD COLLINS, C.M.G.
Mr. R. COOKE.
Mr. J. A. CURTIS.
Dr. G. F. DEACON.
Mr. F. DRUCE.
Mr. F. B. EDMONDS.
Rev. W. ESDAILE.
Mr. H. N. FFARINGTON.
Rev. J. C. FOX.
Dr. LEEDHAM H. FULLER.
Mr. W. V. GRAHAM.
Mr. C. HAWKSLEY.
Col. R. C. HELLARD, C.B.
Dr. A. J. HERBERTSON.
Rev. H. N. HUTCHINSON.
Mr. R. INWARDS.
Mr. A. P. JENKIN.
Dr. J. SCOTT KELTIE.
Mr. BALDWIN LATHAM.
Mr. G. B. LATHAM.
Mr. R. G. K. LEMPFERT.
Dr. E. LEWYS LLOYD.
Capt. H. G. LYONS, F.R.S.
Mr. W. MARRIOTT.
Mr. W. J. MARRIOTT.
Dr. J. D. M'CLURE.
Mr. R. MOND.
Mr. R. W. MUNRO.
Mr. P. P. PENNANT.
Mr. C. SALTER.
Mr. W. SEDGWICK.
Sir J. BENJAMIN STONE, M.P.
Dr. A. STRAHAN, F.R.S.
Mr. G. TALBOT.
Dr. J. J. H. TEALL, F.R.S.
Mr. A. WATT.
Dr. C. THEODORE WILLIAMS.
Representatives of
The Daily Telegraph.
The Morning Post.
The Standard.
The Times.

THE PRESIDENT, in proposing the toast of "The King," said, that the Meteorological Club in one triple toast of six words gave expression to all that on this more formal occasion was expanded into three separate speeches; the sentiment, in expanding, however, was not chilled. When welcoming the President of the French Republic on a recent auspicious occasion, the King—if they were to trust the Press, and if they could not trust the Press, where were they?—first spoke appreciatively of the fine weather. If the King, on such an occasion, spoke first of the weather, then surely the students of the weather at their annual festival should speak first of the King, wishing him long life for his magnificent work as an organiser of peace among the nations, and always the best of weather, as was fitting for the best of Kings.

"God save the King."

THE PRESIDENT, in proposing the toast of "The Queen, the Prince of Wales—Patron of the Royal Meteorological Society—the Princess of Wales, and the other Members of the Royal Family," said that it was their privilege to associate with all such gatherings the names of the Queen and the Royal Family. Every

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passing year showed more strongly the warm interest which the Queen took in all matters appertaining to the welfare of the nation and the advancement of science. Their Patron, the Prince of Wales, was preparing to cross the Atlantic to participate in the commemoration of the origin of Canada, and at the same time the Society which he honoured by his patronage, was sending a representative to take part in the first Conference of Meteorologists of the Empire, initated by the Royal Society of Canada, and to be held in Quebec on the 300th anniversary of the Foundation of that city.

"God bless the Prince of Wales."

Dr. C. THEODORE WILLIAMS, in proposing the toast of "The Visitors," said that it was his great privilege to propose this toast. Their visitors were not only great but good, and he would depend upon that goodness for a sympathetic acceptance of his remarks. He could not be expected to give a complete biography of the many guests present. They greatly regretted the unavoidable absence through indisposition of Lord Strathcona, who would otherwise have been the guest of the evening. Lord Strathcona was not an ordinary man; he was a great personality both in Canada and England. He was a broad-minded and true son of the Empire, and a generous supporter of all deserving institutions. Canada was taking a great lead in a new phase of meteorology by her action in summoning the first Imperial Conference, at which the Royal Meteorological Society would be well represented by its President. The next name he had on the list was that of Captain R. Muirhead Collins, who was looking after the interests in this country, of the Commonwealth of Australia. The various States, which were powerful when independent, would be far more so now that they were federated. Australia was the only country that had organised a complete meteorological service, in which one office issued daily forecasts for a whole continent. Sir Benjamin Stone was a great promoter of public enterprises, and was also well known for his photographic work. The Society owed much to photography, for it depended largely upon photography for obtaining many of its records; hail stones, lightning flashes, wonderfully beautiful forms of clouds, and many others. Mr. E. B. Barnard was the head of one of the most important Water enterprises in the world, and, as Chairman of the Metropolitan Water Board, represented a body which was greatly interested in the question of rainfall. Dr. Teall, Col. R. C. Hellard, the Rev. H. N. Hutchinson, Dr. Scott Keltie, Dr. McClure and Dr. Strahan were also referred to. Dr. Theodore Williams then gave the toast of the "Visitors," coupling with it the names of Captain R. Muirhead Collins and Dr. J. D. McClure.

Captain R. MUIRHEAD COLLINS, in replying to the toast, apologised for his intrusion on the Toast List, but said that he must obey the orders of the President. He greatly regretted that Lord Strathcona was not present to respond to the toast. He himself could hardly be classed among the "good and great," as though he might assume the goodness, the greatness was beyond him. On the other hand, as regards the other guests, he could not answer for their goodness, but was assured of their greatness. Australia would look for great things from its Meteorological Service. They relied upon a thorough knowledge of weather conditions of the country to help them in overcoming certain economic difficulties as they arose. Although Canada was in the forefront in bringing the meteorologists of the Empire together, Australia was not behind in its forecasting department, and the fact that Australia was the only great continent that published a daily weather chart had been referred to by the proposer of the toast. Federation had done that for them, and in federating the Meteorological Department it had made a great advance.

Dr. J. D. MCCLURE, replying to the toast in a humorous speech abounding in anecdote, said that he thanked the Society for the privilege of dining with

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them. It had been said that the guests were a wonderful lot of people, and he was sure the guests agreed. Such a truth required to be frequently stated. He did not think any of them had been more fortunate than he, for at his table they had agreed that this should not be the last time they four would dine together. When at Cambridge he had been taught that there were three points to be observed in making a speech. First, to spend a few minutes getting to the subject, then another few minutes skating round it, and finally a few minutes in getting away from it, the last being the most difficult of all, but with renewed thanks, he would resume his seat.

PART SONG—"Sweetly blows the Western Wind."

Mr. E. B. BARNARD, M.P. (Chairman of the Metropolitan Water Board), said that the privilege of proposing the toast of the evening—"The Royal Meteorological Society"—fell to his lot. As far as he personally was concerned, it was a novel position for him to be associated with the Society, and he appreciated it with no mock humility. He was well acquainted with the objects and aims of the Society, although he had not previously been associated with them, and even now he had some difficulty in pronouncing the name of the Society clearly; that was not, however, the result of their hospitality! The Body of which he was Chairman had to concern themselves with water when it arrived on the ground, and they took advantage of the statistics prepared by the Society, realising that the real source of their water-supply was the clouds. He understood that the Fellows of the Society discovered facts of great interest regarding the weather, and placed their results before the public. Weather prophets were a reckless race, and the general attitude of the public towards them was that of suspicion. Engineers and geologists walked arm in arm, and the Society's work was of great value to both; it was done unselfishly and ungrudgingly. They were collecting and collating valuable evidence, and doing so honestly and to the best of their ability; giving up their time for the sake of wider knowledge. He found that the Society's figures were generally complete, and the authority he represented knew the value of sizing them up to the best advantage.

THE PRESIDENT said that he had great pleasure in responding to the toast, and he thanked the proposer for his frank and kindly speech, and for the stress he laid on the importance of the practical applications of meteorology, an aspect which, perhaps, was not so often dealt with as it deserved to be.

The Society had prospered in the past year. It bore its fifty-eight years lightly, and was still growing younger in the added strength of new Fellows. It had delighted to honour the distinguished French meteorologist, M. Teisserenc de Bort, with the Symons Gold Medal for his magnificent work in founding the scientific study of the upper air. It had been delighted and honoured by the eminent chief of the Prussian Meteorological Service, Dr. Hellmann, whose unique studies of old records enabled him to expound the Dawn of Meteorology as no one else could, and who pleased them by recalling how prominent a part had been taken by English students of weather even in the middle ages.

During the year the Society had endeavoured to stimulate the study of Meteorology in elementary schools by arranging a prize essay competition on weather and climate for teachers. It was gratifying to find how widely the subject had been taken up, for nearly 200 essays had been received. The Society hoped to base upon these essays a systematic syllabus, and to direct it into fruitful channels. Education in the matter of weather study was necessary for more than school children. Some portions of the daily press were painfully credulous and uncritical in dealing with long-range weather predictions, which were pure guesswork, not worth the while of a scientific man to confute, though not infrequently very confusing to the untrained mind. The Society was

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quietly endeavouring to find out the laws which governed the weather, and to this end they were not only studying the occurrences taking place in the air at the surface, but, by means of balloons and kites, they were assisting in obtaining records of what was happening in the upper regions of the atmosphere. The study of the upper air was unquestionably the most promising field of work at the present time, and important results could confidently be expected from it.

While the Society spent much time in forwarding researches which would ultimately benefit the public, their modest light was not set on so high a candlestick as they humbly thought it deserved. They received no assistance from public funds, and he ventured to think that no other London Scientific Society of equal age, of equal numbers, or of equal utility was unprovided with free rooms in a Government building, or at least some subsidy towards its maintenance. They received no recognition either in the way of representation on the Visiting Bodies of such institutions as the Greenwich and Kew Observatories, which were largely devoted to Meteorology, yet similar Societies concerned with other activities of those bodies were represented. They did not complain, though they were conscious of the anomaly; and it was well to state this occasionally, were it only to warn the public not to measure their aims and their solid achievements by the easy, though not always just, standard of official recognition. The aims of all scientific societies were necessarily high, and ought to be sufficing, but it was none the less an incentive to have them recognised. They had, he feared, sometimes allowed their higher aspirations to be forgotten. Perhaps in their earlier history they had not always told the outside world clearly enough that they were not simply laying up a wealth of recorded observations, but they had in view the discussion of the accumulated data in order to lead further. That time, if it ever was, had passed. They recognised, and they did not hesitate to proclaim, that they had before them a problem of immense complexity, a problem subject to the sway of innumerable and almost incalculable influences, not always capable of being dealt with by methods which could be classified under one of the great branches of science. He did not think it was always possible to deal with the problems of meteorology by laboratory, or experimental, methods, which usually involved the pursuit of an isolated clue, and the cutting away or ignoring of disturbing causes, which were really as essential to final result as the single line selected. Physicists, chemists and astronomers, he was almost inclined to suspect, were sometimes apt to misjudge the meteorologist. He feared that at times they even failed to appreciate the essentially scientific character of the work of the student of the forces of Nature as they were exemplified on the land's surface, in the water and in the air.

The title of their Society he might remind them was not limited by any territorial restriction; they were a Royal Society and their immediate sphere included all the King's dominions, although as regards one small branch of their work—the collection of observations—they did not invade the territory of their sister Society of Edinburgh,—in all else they were as circumambient as the air itself, for the whole atmosphere was their parish. Nearly a quarter of their Fellows lived outside England; the address of 35 was in India, of 34 in Africa, of 32 in foreign countries, of 13 in Australia and New Zealand, but only of two in Canada. Was it any wonder that the Society was sending a mission to the Dominion on the occasion of the Pan-Meteorological Conference which the Royal Society of Canada had convened! They hoped to see, as a result of this Conference, a closer union between the working meteorologists of the Empire. They had worked long for it in this country, and now that the Dominion of Canada had taken the first step in calling the Conference, and the Commonwealth of Australia had

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responded by sending the chief of their newly created Federal Meteorological Service, it only remained for India, Africa, and the Isles of the Sea to fall into line. The Sea itself, thanks to the Navy, was there already.

OLD ENGLISH MELODY.—"Blow high, blow low."

Mr. BALDWIN LATHAM said that he had very great pleasure in proposing the toast of "Kindred Institutions." Although reminded by the President of the somewhat isolated position of the Society, they were doing good work which was useful to other institutions. Many institutions depended largely upon meteorology; he might refer to the Geological Survey and Geological Society, and, if he might be permitted, he would like to urge upon the Geological Survey to take a leaf out of the book of the United States Geological Survey, who not only studied the geology of the country, but also gauged the rainfall, published records of rainfall, the flow of water off the ground, floods, low water, etc., which were always ready to hand in carrying out water works investigations, and were of immense value. They did not trespass upon the borders of the Scottish Meteorological Society, but worked with them with a good will. The Meteorological Office was the only department issuing forecasts in advance, and these were only for a limited period. The Institution of Civil Engineers had many members who took a great interest in meteorology, and some of the past Presidents of the Institution had also been prominent Fellows of the Society. The Institution, as a body, gave the Society encouragement by placing their splendid meeting-room at the disposal of the Society. The Ordnance Survey was a body upon which they relied for the making of their maps; they had kept meteorological and other records in the past, though they did not seem to do so at present. The Royal Geographical Society were doing good service in exploration. The Aeronautical Society aided them in the study of the upper air. Last, but not least, he would mention the British Rainfall Organization, most valuable for its study of the fluctuations of the water-supply. It was started by the late Mr. G. J. Symons, who might well be considered its patron saint, and it was being continued by the occupant of the Presidential chair, Dr. H. R. Mill, and could not be in better hands. With the toast he would couple the names of Dr. J. J. H. Teall, F.R.S., Capt. H. G. Lyons, F.R.S., and Mr. Andrew Watt.

Dr. J. J. H. TEALL said that he regarded it as a great honour to be the first to reply to the toast, especially as some other Institutions might seem to have a prior claim to this distinction. If he might be permitted to refer to Mr. Baldwin Latham's critical remarks about the Geological Survey, he could only say that he entirely sympathised with those remarks. It always seemed to him that the bearing of the work of the Geological Survey in economic matters was particularly in two directions, *i.e.* that of coal-mining, and that of water-supply and sanitation. He was well aware that their work in the latter direction would not bear comparison with that of the Institution referred to, but he would like to mention that during the past few years they had done something. The Geological Survey had published a series of memoirs on the underground water-supply of Counties, and had been fortunate in securing the services of Dr. Mill to prepare a series of rainfall maps for incorporation in those memoirs. He would also point out that a Committee of the Royal Geographical Society, of which his colleague, Dr. Strahan, was a member, were making a study of certain river basins from the point of view which Mr. Latham had referred to. The Geological Survey and Geological Society were classed as kindred Institutions, and if time permitted, it would not be difficult to prove the legitimacy of their claim to that position. Dr. Williams had said that in a certain sense geology was a monument to meteorology; and this was undoubtedly true, for many rocks gave evidence of the meteorological condi-

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tions under which they were formed. It is now known, for example, that arid climates have prevailed more than once in Northern Europe, and that glacial conditions have occurred at different periods of the world's history and in different places. He referred also to the work of Mr. Harmer on the influence of the winds upon climate during the Pleistocene epoch, and concluded by expressing the hope that some day or other weather charts of the world would be issued under the auspices of the Royal Meteorological Society.

Captain H. G. Lyons said that he supposed he had been selected to reply to the toast of "Kindred Institutions" because he was conversant with an area outside the British Isles. His knowledge was not world-wide, but only extended to the land of Egypt, the Sudan and the Nile. Mr. Baldwin Latham had referred to the question of rainfall and river variations, but in Egypt they had next to none of the one, and only one of the other. In a small country like Egypt some concentration of work was necessary, and the Survey Department had to collect observations relating to more than one science; thus the meteorological and geological work fell to the lot of one Department. The opening up of the Sudan was of recent date, but they were gradually establishing a network of stations from which they hoped to receive valuable results, for the rise and fall of the Nile entirely depended upon the rainfall of the Abyssinian mountains, and this was a part of the great monsoon system of the Indian Ocean. But though observations were essential, their discussion and study must not be allowed to fall into arrears; when the Survey Department took over the control of the Abassia Observatory, he had found a pile of documents, and on making enquiry concerning them, found they were the result of daily observations taken at 2.30 p.m., which were made in answer to an enquiry received some fifteen years previously. The name and address of the person making the enquiry had been lost, but the observations had been allowed to go on accumulating; they had now been compiled, and so were not entirely useless. He could fully sympathise with Dr. Mill on the problem of meteorological observations to which he had referred. The climatic conditions of north-east Africa were less complex than in many parts of the British Empire, and the solution of the various problems should prove a less difficult task. The climate of Egypt was not always as arid as it is to-day. There were opportunities for meteorological observations everywhere, and simple observations, if made carefully and conscientiously, would always be of value.

Mr. Andrew Watt, in responding to the toast of "Kindred Institutions," said that it was a great honour to reply in such a goodly company for the Scottish Meteorological Society. It was indeed a very significant courtesy that the name of the Scottish Society should appear on the Toast List. Beyond all other sciences that of Meteorology should be independent of international boundaries, and it was fortunate for the happy relations between Scotland and England that the Royal Meteorological Society had for at least one term of office a Scot in its Presidential chair. As regards the distinguished Director of the Meteorological Office, he might recall a story of a Scot who was somewhat boastfully upholding the literary fame of his country. "There's Robbie Burns," he said, "a Scotsman; Sir Walter Scott, a Scotsman; Thomas Carlyle, a Scotsman. They're all Scotsmen." "Yes," said an Englishman, "but what about Shakespeare?" "Well," was the reply, "I'm not just prepared to aver that Shakespeare was a Scotsman; but this I will say, that his abilities would justify the inference." And so of Dr. Shaw, if he was not a Scot, he might have been.

Part Song.—"Our Ship now goes with the Pleasant Gale."

Mr. F. Campbell Bayard in a few words proposed a vote of thanks to the Chairman, remarking that they all knew what Dr. Mill had done for the Society. At a great sacrifice of time he had decided to represent the Society at

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the Meteorological Conference in Canada. They all wished him a pleasant voyage.

THE PRESIDENT, in expressing his thanks, referred to the novel arrangement of the tables, and hoped that by arranging the party in little groups of four the social opportunities of the evening had been turned to the best account.

QUARTET.—"Lovely Night."

The proceedings then terminated.

The Music was under the direction of Mr. H. Schartau.

PROCEEDINGS AT MEETINGS OF THE SOCIETY.

May 20, 1908.

Ordinary Meeting.

Dr. HUGH ROBERT MILL, President, in the Chair.

ROBERT VAUGHAN GOWER, Ferndale Lodge, Tunbridge Wells;
DAVID HANSON, Salterlee, Halifax;
WILLIAM FRANCIS KEATES, Cannelton, Indiana, U.S.A.;
ALBERT LANCELOT LANG, 3 Avenue Road, Isleworth, W.;
WILFRID RAVENSHAWE FELLOWES LUKIS, Yokohama, Japan;
SAMUEL JAMES AUGUSTUS MILLS, Preston Road, Blackburn;
BASIL RONALDS, Swainshill, Hereford; and
Capt. HUGH WILLIAMS, Ismailia, Egypt,
were balloted for and elected Fellows of the Society.

THE PRESIDENT said that before commencing the regular business, he would like to remind the Fellows present that the Annual Dinner of the Society would take place at the Trocadero Restaurant on Tuesday, June 16. He wished to impress upon them the importance of being present and also bringing their friends. The Society was inviting a certain number of distinguished guests, and one of them, Lord Strathcona, the High Commissioner for Canada, had already accepted the invitation. The President stated that the Society was taking part in a Conference of Meteorologists of the British Empire called by the Royal Society of Canada to meet in Quebec in July. This was, he believed, the first occasion in which one of the Colonies had taken the initiative in bringing together a scientific Conference. The Dinner would take place before the next meeting of the Society, and he trusted that country members arriving for one function would remain for the other.

The following communications were read:—

1. "UPPER AIR OBSERVATIONS IN EGYPT." By B. F. E. KEELING, M.A. (p. 259).

2. "BALLOON EXPERIMENTS IN BARBADOS, NOVEMBER 6-8, 1907." By Professor J. P. D'ALBUQUERQUE, M.A. (p. 265).

3. "OBSERVATIONS ON THE COLOUR OF LIGHTNING, MADE AT EPSOM, 1903-1907." By SPENCER C. RUSSELL, F.R.Met.Soc. (p. 271).

June 17, 1908.

Ordinary Meeting.

Dr. HUGH ROBERT MILL, President, in the Chair.

ARTHUR CAPEL VALENTINE BAINES, Somerset East, Cape Colony;

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JAMES NICOLL HOOD, Woodside, Muirfield Road, Inverness;
BERTRAM FRANCIS EARDLEY KEELING, M.A., Helwân, Egypt;
VINCENT CLAUDE LARGE, 5 Ashbourne Road, Fulwood Park, Liverpool;
Hon. CHARLES STEWART ROLLS, M.A., South Lodge, Rutland Gate, S.W.; and
Capt. THOMAS SHAILER WESTON, 18 Clarendon Road, Holland Park, W.; were balloted for and elected Fellows of the Society.

The following communications were read:—

1. "AN ELEMENTARY EXPLANATION OF CORRELATION: ILLUSTRATED BY RAINFALL AND DEPTH OF WATER IN A WELL." By R. H. HOOKER, M.A., F.R.Met.Soc. (p. 277).

2. "THE HONG-KONG TYPHOON, SEPTEMBER 18, 1906." By LAWRENCE GIBBS, Assoc.M.Inst.C.E. (p. 293).

CORRESPONDENCE AND NOTES.

The Franco-British Exhibition and Meteorology.

The Executive Committee of the Franco-British Exhibition, when arranging for the Exhibition at Shepherd's Bush, decided to organise a British Science Section, which should deal with all forms of scientific research, and should include historical apparatus, which has aided in the advancement of scientific knowledge. A building containing 14,000 square feet of floor space was erected for the purpose, and a Science Committee appointed for carrying out the scheme. Subsequently, for the purposes of organisation, fifteen sub-committees were formed. That for Meteorology consisted of Mr. W. W. Bryant, Major Baden-Powell, Mr. E. S. Bruce, Capt. E. W. Creak, F.R.S., Dr. C. Chree, F.R.S., Mr. R. H. Curtis, Capt. C. Hepworth, Mr. R. G. K. Lempfert, Dr. W. J. S. Lockyer, Mr. W. Marriott, Dr. H. R. Mill, Mr. W. E. Plummer, Dr. A. A. Rambaut, F.R.S., Dr. W. N. Shaw, F.R.S., and Mr. C. T. R. Wilson, F.R.S. Dr. Shaw was the convener.

A large and interesting collection of valuable instruments, apparatus, maps, charts, diagrams, photographs, books, models, etc. has been got together, and this forms an important section in the Science building.

The Exhibits are arranged under the following sections:

A. Collection and discussion of observations from Warships and the Mercantile Marine.
B. Observatories.
C. Climatology.
D. Rainfall and Hydrometrical Statistics.
E. Telegraph Reporting.
F. Experimental Investigations.
G. Illustrations of Meteorological Work of Special Character.
H. History and Literature of Meteorology.
I. Atmospheric Electricity.

The principal exhibits have been lent by the Meteorological Office, the Royal Meteorological Society, the National Physical Laboratory, the Royal Observatory, Greenwich, the Radcliffe Observatory, Oxford, and Dr. H. R. Mill. Other exhibits have been contributed by Mr. J. Aitken, F.R.S., Mr. E. S. Bruce, Mr. A. W. Clayden, Messrs. J. W. Gray and Sons, Dr. W. J. S. Lockyer, Mr. W. Marriott, Mr. W. E. Plummer, Mr. J. Tennant, and Capt. D. Wilson-Barker.

It was intended that a working Climatological Station with instruments in position should be equipped by the Royal Meteorological Society in the grounds of the Exhibition, and that observations should be made daily at 9 a.m. and 9 p.m. Unfortunately, the Exhibition authorities did not provide a site suitable for the exposure of the instruments, so the station could not be arranged.

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RECENT PUBLICATIONS.

Barometric Gradient and Wind Force. Report to the Director of the Meteorological Office on the Calculation of Wind Velocity from Pressure Distribution, and on the Variation of Meteorological Elements with Altitude. By ERNEST GOLD, M.A. Published by the Authority of the Meteorological Committee. London, 1908. 4to. 44 pp. and 15 pl. Official Copy, M.O. No. 190.

This paper is divided into two sections. The first deals with the calculation of wind velocities from the distribution of the isobars according to the theory of Ferrel, and Guldberg and Mohn. The second contains an account of the results obtained from kite and balloon ascents in Germany and in England during 1905 and 1906, and a comparison between the values obtained for the wind velocity and direction at 1000 metres altitude by experiment and according to calculation.

Dr. Shaw, in the preface to this Report, points out that the relation of wind force to barometric gradient is a fundamental question in modern meteorology.

Maryland Weather Service. Volume II. Baltimore, 1907. 8vo. 515 pp.

This is the second of a series of *Reports* dealing with the climatic features of Maryland. The first volume issued by this Service was general in character, and presented all that was then known regarding the physiography and meteorology of the State. The present volume contains a very exhaustive "Report on the Climate and Weather of Baltimore and Vicinity," and represents the results of many years' study of the Baltimore region. It is doubtful if the weather of any district has been so thoroughly studied as this region has been by Dr. Fassig.

The Report is divided into two parts. The first deals with the average and extreme values of the meteorological elements recorded in the city of Baltimore. The discussion is based upon observations extending over a period of nearly a century. The second part deals with types of weather experienced in Baltimore and the vicinity. The Report is profusely illustrated, being accompanied by 24 plates and 173 illustrations, many of which are in colours.

A summary of the principal climatological results for the years 1871-1904 are given in the following table:—

MONTHLY RESULTS OF CLIMATOLOGICAL OBSERVATIONS, BALTIMORE, 1871-1904.

MONTHS.	Pressure.	Temperature.						Relative Humidity.	Amount of Cloud.	Rain.	
		Means.			Extremes.					Amount.	No. of Days.
		Min.	Max.	Range	Mean.	Min.	Max.				
	ins.	°	°	°	°	°	°	%		ins.	
January	29·995	27·4	40·6	13·2	34·0	−6	73	69·5	5·9	3·20	12
February	29·968	28·5	42·4	13·9	35·5	−7	78	66·5	5·0	3·70	11
March	29·889	34·4	49·6	15·2	42·0	5	82	64·9	5·3	3·99	13
April	29·877	44·8	61·6	16·8	53·2	24	94	60·1	5·7	3·27	11
May	29·852	55·6	72·9	17·3	64·3	34	96	63·0	5·8	3·63	12
June	29·851	64·5	81·8	17·3	73·1	47	99	66·6	5·1	3·78	10
July	29·850	69·4	85·8	16·4	77·6	55	104	66·4	4·9	4·66	12
August	29·869	67·3	83·3	16·0	75·3	51	100	69·2	4·6	4·20	11
September	29·946	60·4	76·5	16·1	68·4	39	101	70·4	4·3	3·85	9
October	29·942	49·2	65·6	16.4	57·4	30	90	67·6	5·0	2·99	9
November	29·976	38·7	53·1	14·4	45·9	15	79	65·8	4·9	2·99	10
December	29·988	30·3	43·8	13·5	37·1	−3	73	67·2	5·0	3·07	11
Year	29·917	47·5	63·1	15·6	55·3	−7	104	66·5	5·1	43·33	131

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National Antarctic Expedition, 1901-1904. *Meteorology, Part I. Observations at Winter Quarters and on Sledge Journeys, with Discussions by Various Authors.* Prepared under the Superintendence of the Director of the Meteorological Office with the Co-operation of a Committee of the Royal Society. Published by the Royal Society, 1908. 4to. London. (14 + 548 pp., 15 plates, and 5 charts.)

The meteorological work of this Expedition was under the charge of Lieutenant C. Royds, who gave a very interesting account of the work done, and the difficulties which had to be contended with, at the Meeting of the Royal Meteorological Society in November 1904. (*Quarterly Journal*, 31, 1905, p. 1.)

This volume contains the meteorological Journal of the *Discovery*, giving two-hourly observations from February 9, 1902, to February 15, 1904, and in addition the meteorological observations made at Erebus Island Camp, lat. 77° 51′ S., long. 166° 45′ W., and on the various sledge journeys from winter quarters, are printed *in extenso*. These observations extend over 246 pages. Summary tables of the *Discovery* Expedition, and of the German, Swedish, and Scottish National Expeditions, are also given, together with those of the relief ship *Morning*. The results have been discussed in the following papers, which are printed in the volume:—"Climatology of South Victoria Land, and the Neighbouring Seas," by M. W. Campbell Hepworth; "Notes on the Observations of Temperature of the Winter Quarters of the *Discovery*," by Dr. Charles Chree; "Notes on Open-air Temperature, Stream Temperature, and on Terrestrial Radiation," by W. H. Dines; "Notes on the Readings of the Aspiration Psychrometer and of the Dry and Wet-bulb Thermometers, and on the Observations of Evaporation and Precipitation, and of the Evaporation of Ice," by W. H. Dines; "Notes on the Observations of Barometric Pressure," by R. H. Curtis; "Discussion of the Observations of the Direction and Force of Wind at Winter Quarters and on the Sledge Journeys," by R. H. Curtis; "Notes on the Records of Sunshine and the Observations of Clouds," by R. H. Curtis; and "Discussion of the Observations of Atmospheric Electricity," by C. T. R. Wilson. Lieutenant Royds contributes some notes on the meteorological instruments and their exposure; and Dr. E. A. Wilson a series of beautiful plates illustrating solar and cloud phenomena. Dr. Shaw, in the preface, sums up what appear to be the salient features of the climate, according to the two years' experiences of the explorers, as follows:—

"Although the winter quarters were regarded as an exceptionally warm position in relation to others in the locality, temperature ranged from a maximum of only 42° F. to a minimum of −58°·3 F. Fluctuations are extraordinarily rapid and violent at all seasons; they are sometimes, but not always, associated with changes of wind direction. Polar winds often bring with them an increase of temperature.

"The daily range is large in consequence of the sudden fluctuations, but the mean diurnal variation, as represented by the average of the two-hourly readings, amounts to only 3° in midsummer and 1° in midwinter. The time of maximum, as regards the latter, is rather dubious, but there is evidence of a diurnal and semidiurnal oscillation of temperature even in the Antarctic night.

"The summers were remarkably cold. Very few days gave a mean temperature above the freezing-point. The highest mean temperature for any month was 26°·2 F., the lowest −21°·0 F. The air is remarkably dry and transparent, fog is comparatively infrequent; precipitation is slight, but there may be deep drifts of snow. Sunshine is remarkably abundant; the total for 1903 equalled that for Scilly, and in December of that year an average of 16 hours per day was registered. The sun's rays are intensely hot, and terrestrial radiation extremely vigorous.

"Pressure ranged between 30·181 and 28·140 ins., the two extremes occur-

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ring in consecutive months of 1902. The barometer stands high as compared with the values obtained for other positions in the Antarctic. The sequence of pressure changes as shown on the barographic records presents no very noteworthy peculiarities, and the use of the barometer for anticipating coming weather is less effective than in this country.

"The pressure observations show the common semidiurnal oscillation. It amounts to 0·002 in., with maxima at about 10 a.m. and 10 p.m. at all seasons of the year. The variation of 24 hours' period has, on the average, an amplitude of twice that amount, but the times of maximum are different at different seasons.

"The changes of pressure in high southern latitudes may be regarded as associated with the passage of cyclonic depressions much in the same way, *mutatis mutandis*, as elsewhere.

"The surface winds are chiefly Easterly. Northerly and Southerly winds occur, but winds from between the South-west and North-west are almost unknown. The chief characteristic of the wind is its gustiness. Gales are experienced from every quarter between North-east round to South-west on the Eastern side, but, on the whole, they are not so frequent as in the British Isles.

"The direction and motion of the lower clouds may be from any point of the compass. The resultant is a moderate frequency from the South-east; there is a marked deficiency as regards the West.

"The resultant motion of smoke from Mount Erebus is from the South and West, and that of the upper clouds from the West.

"Subject to some uncertainty on the state of the instrument, the mean electric force potential is rather lower than at Kew, but abnormally high in drifting snow or ice crystals. A diurnal variation is shown in summer with a maximum in the middle of the day, and a minimum in the early morning hours. The seasonal variation has a maximum in summer and a minimum in winter.

"No relation is shown between potential and aurora."

The observations and results given in this volume are a most valuable addition to our knowledge of the conditions of the Antarctic regions.

There still remain for publication the discussions of the special features of the traces from the recording instruments, obtained at the winter quarters, and of about one thousand synchronous charts of the regions south of 30° S. lat. which have already been prepared from the daily observations at Greenwich noon contributed by international co-operation.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of more general interest.

Abbot, C. G., and Fowle, F. E., Jr.—Recent Determinations of the Solar Constant of Radiation. *Terrestrial Magnetism, Baltimore*, **13**, 1908 (79-82).

Angot, A.—Sur le calcul des observations pluviométriques. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (125-128).

Angot, A.—Sur la mesure de la neige. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (157-159).

Barnes, H. T.—Formation of ground- or anchor-ice, and other natural ice. *Nature, London*, **78**, 1908 (102-104).

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Bates, Rev. D. C.—Report upon Dry Period and Rain-making Experiments at Oamaru, New Zealand. *Symons' Met. Mag., London*, **43**, 1908 (107-111, 137-138, 156-159).

Blair, W. R.—Upper Air Temperatures for January, February, and March. *Bull. Mount Weather Obsy., Washington*, **1**, 1908 (176-206 and 4 plates).

Brazier, C. E.—Recherches expérimentales sur la compensation des barographes anéroïdes des systèmes Richard et Naudet. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (165-169).

Brunhes, M. B.—Sur la mesure directe de la composante verticale du magnetisme terrestre. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (129-131).

Bryant, W. W.—A Singular Atmospheric Storm at the Royal Observatory, Greenwich, July 12, 1908. *Observatory, London*, **31**, 1908 (313-315).

Buchanan, J. E.—Early Meteorological Data for Saline, Mich. *Monthly Weather Rev., Washington*, **36**, 1908 (105-107).

Burbank, J. E.—Some Microseismic Tremors and their Apparent Connection with Barometric Variations. *Terrestrial Mag., Baltimore*, **13**, 1908 (1-20).

Calvert, P. P.—A Collection of Mean Annual Temperatures for Mexico and Central America. *Monthly Weather Rev., Washington*, **36**, 1908 (93-97).

Cleef, E. van.—Is There a Type of Storm Path? *Monthly Weather Rev., Washington*, **36**, 1908 (56-58).

Cordeiro, F. J. B.—Die Vorherbestimmung der Bahnen der Orkane. *Meteor. Zeits., Brunswick*, **25**, 1908 (201-206).

Dannevig, H. C.—On Some Peculiarities in our Coastal Winds and their Influence upon the Abundance of Fish in Inshore Waters. *J. Roy. Soc., N.S. W.*, **41**, 1907, *Sydney*, 1908 (27-45).

Dennett, F. C.—The Brilliant Midnight Heavens of July 1 and 2 (1908). *Knowledge, London*, **5**, 1908 (187-188).

Duckworth, A.—A Comparison of the Rainfall of Sydney and Melbourne, 1876-1905. *J. Roy. Soc., N.S. W.*, **41**, 1907, *Sydney*, 1908 (190-195).

Du Faur, E.—The Effect of the Polar Ice on the Weather. *J. Roy. Soc., N.S. W.*, **41**, 1907, *Sydney*, 1908 (176-189).

Fernie, F.—Notes on Some Lightning Discharges. *Elect. Rev., London*, **63**, 1908 (314-315).

Field, J. H.—Kite Flights made at Belgaum during the Premonsoon and Monsoon Periods in 1906. *Indian Met. Memoirs, Calcutta*, **20**, 1908 (19-32 and 14 pl.).

Foester, K.—Die Föhnerscheinungen im Riesengebirge. *Wetter, Berlin*, **25**, 1908 (131-134).

Garrigou-Lagrange, P.—La pluie et le régime des cours d'eau. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (132-134).

Gayer, C. S.—The Evaporating Power of the Air at the New York Botanical Garden. *Monthly Weather Rev., Washington*, **36**, 1908 (63-64).

Grossmann, Prof.—Die Beziehung zwischen den Temperaturen des Nordatlantischen Ozeans und von Nordwest und Mitteleuropa. *Ann. d. Hydrog. u. Marit. Met., Berlin*, **36**, 1908 (333-348).

Hamburg, Deutsche Seewarte.—Monatskarten für den Indischen Ozean. *Ann. d. Hydrog. u. Marit. Met., Hamburg*, **36**, 1908 (285-288).

Die Eisverhältnisse an den deutschen Küsten im Winter 1907-08. *Ann. d. Hydrog. u. Marit. Met., Hamburg*, **36**, 1908 (288-295).

Henry, A. J.—Accidental Variations in Atmospheric Pressure in the United States. *Monthly Weather Rev., Washington*, **36**, 1908 (53-56).

Henry, A. J.—Temperature Inversions at the Mount Weather Observatory. *Bull. Mount Weather Obsy., Washington*, **1**, 1908 (143-160).

Hergesell, H.—The Present and Future State of Maritime Meteorology. *Monthly Weather Rev., Washington*, **36**, 1908 (58-61).

Hill, W.—The Whirlwind in North Hertfordshire on June 4, 1908. *Symons' Met. Mag., London*, **43**, 1908 (113-116).

Jackson, W. H.—The Law of the Earth's Nocturnal Cooling. *Monthly Weather Rev., Washington*, **36**, 1908 (103-105).

Jennings, T. B.—Climate of Kansas. *Monthly Weather Rev., Washington*, **39**, 1908 (88-92).

Digitized by Google

Joester, K.—Die Föhnerscheinungen im Riesengebirge. *Wetter, Berlin*, **25**, 1908 (102-106).

Köhler, Karl.—Registrierungen des luftelektrischen Potentialgefälles an nahe benachbarten Stationen. *Meteor. Zeits., Brunswick*, **25**, 1908 (155-162, 289-299).

Kimball, H. H.—A new Formula for Computing the Solar Constant from Pyrheliometric Observations. *Monthly Weather Rev., Washington*, **36**, 1908 (108-110).

Knoch, K.—Die Entwicklung unserer Kenntnis des Windschutzes bei der Aufstellung der Regenmesser. *Wetter, Berlin*, **25**, 1908 (97-102, 129-131, 151-158).

Krčmář, J.—Zum Klima von Sitka. *Meteor. Zeits., Brunswick*, **25**, 1908 (315-321).

Kremser, V.—Der Einfluss der Grossstädte auf die Luftfeuchtigkeit. *Meteor. Zeits., Brunswick*, **25**, 1908 (206-215).

Lockyer, W. J. S.—"Ribbon" or "Band" Lightning. *Knowledge, London*, **5**, 1908 (117-119, 151-154).

McAdie, A. G.—Forecasting on the Pacific Coast. *Monthly Weather Rev., Washington*, **36**, 1908 (98-101).

Maillet, E.—Résumé des observations centralisées par le service hydrométrique du Bassin de la Seine pendant l'année 1906. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (101-114).

Maillet, E.—Sur la crue de la Seine en Février-Mars, 1908. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (115-116).

Mallock, A.—Note on the Ascent of Meteorological Balloons and the Temperature of the Upper Air. *Proc. Roy. Soc., London, A*, **80**, 1908 (530-534).

Maurer, J.—Die Wärmeabnahme mit der Höhe in den Schweizer Alpen. *Meteor. Zeits., Brunswick*, **25**, 1908 (241-246).

Mehring, H.—Aus den Erfahrungen einer neuen Dienststelle. *Wetter, Berlin*, **25**, 1908 (138-144).

Mengel, O.—Sur la constance de la température des eaux thermales des Pyrénées-Orientales. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (160-164).

Michelson, W. A.—Ein neues Aktinometer. *Meteor. Zeits., Brunswick*, **25**, 1908 (246-253).

Mill, H. R.—The Geographical Distribution of Rainfall in the British Isles. *Geog. J., London*, **32**, 1908 (59-65).

Mohn, H.—Neue Studien über das Hypsometer. *Meteor. Zeits., Brunswick*, **25**, 1908 (193-200).

Mossman, R. C.—The South Orkneys in 1907. *Scot. Geog. Mag., Edinburgh*, **24**, 1908 (348-355).

Rickmers, W. R.—The Climatology of West Turkestan. *Geog. J., London*, **31**, 1908 (647-649).

Schulze, P.—Ludwig Friedrich Kämtz. *Wetter, Berlin*, **25**, 1908 (106-111, 145-151).

Smirnov, D.—Über das Aktinometer Violle-Savélief. *Meteor. Zeits., Brunswick*, **25**, 1908 (299-312).

Sprung, A.—Die registrierende Laufgewichtswage im Dienste der Schnee- Regen und Verdunstungsmessung. *Meteor. Zeits., Brunswick*, **25**, 1908 (145-154).

Strong, W. W.—Radium: its Properties, Distribution, and Influence on the Atmosphere. *Monthly Weather Rev., Washington*, **36**, 1908 (64-70).

Suring, R.—Die verheerenden Gewitter und Regenfälle in Nordeutschland vom 20 bis 24 Mai 1908. *Wetter, Berlin*, **25**, 1908 (121-129).

Tietz, G.—Orkan im Arabischen Meer vom 23 Oktober bis 3 November 1906. *Ann. d. Hydrog. u. Marit. Met., Berlin*, **36**, 1908 (156-163).

Weber, O. R.—Das Observatorium erster Ordnung zu Quixeramobim, Staat Ceará, Nordbrasilien. *Meteor. Zeits., Brunswick*, **25**, 1908 (162-167).

Wilson, C. T. R.—On the Measurement of the Atmospheric Electric Potential Gradient and the Earth-air Current. *Proc. Roy. Soc., London, A*, **80**, 1908 (537-547).

Woeikof, A.—Zur Kenntnis des Regenfalles in Niederländisch-Indien. *Meteor. Zeits., Brunswick*, **25**, 1908 (168-174).

Worth, R. H.—Rainfall in Devon, especially for the Years 1896-1905. *Trans. Devon Assoc., Plymouth*, **39**, 1907 (223-230 and 4 pl.).

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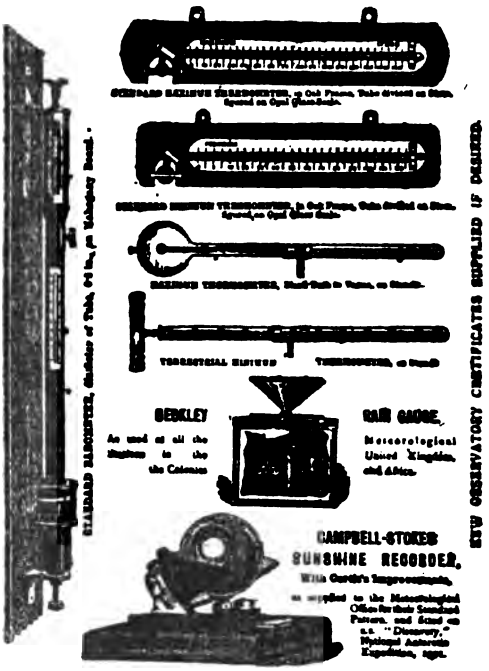
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DECEMBER .	„	16, „	APRIL . .	„	21, „
JANUARY .	„	20, 1909	*MAY . .	4.30 p.m.	19, „
FEBRUARY .	„	17, „	*JUNE . .	„	16, „

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EDITED BY

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„ 2. Map showing Position of the Phenological Stations, 1908.

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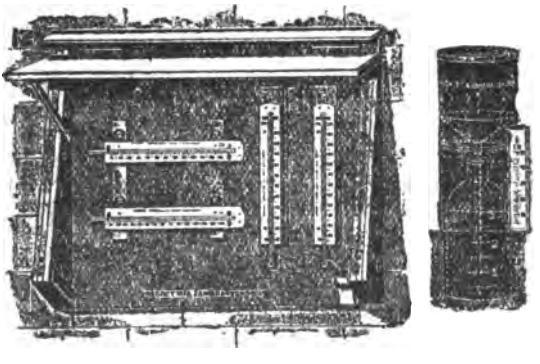
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VOL. XXXV.] JANUARY 1909 [No. 149

GERMAN METEOROLOGICAL SOCIETY—TWENTY-FIFTH ANNIVERSARY, 1908.

By HENRY HARRIES, F.R.Met.Soc., Member of the German Met. Soc.

[Read November 18, 1908.]

JUST a quarter of a century ago to-day, as the result of a conference held at the Deutsche Seewarte, Hamburg, on November 17 and 18, 1883, the German Meteorological Society was formed, with Dr. von Neumayer as its first President. It is not necessary now to dwell upon the universally acknowledged fact—to which that great recorder of the progress of modern meteorological knowledge, the *Meteorologische Zeitschrift*, also bears abundant testimony—that in the interval the Society has far more than justified its existence, and has earned the unqualified praise of all who are interested in the science.

Owing to the extensive area of the German Empire rendering it impossible to hold frequent meetings, it was from the first deemed desirable to enrol the members in local branches, so as to get over this difficulty. The Hamburg-Altona branch was formed on January 14, 1884; the Berlin one on January 29; the Munich one on February 13; and so on. This sufficiently explains why the Society as a whole holds a general meeting only once in two or three years, at some convenient holiday season, when members from all parts of the country can be brought together. For many years it was the practice for the German Geographical and the Meteorological Societies to combine their forces so as to attract a goodly company at these occasional reunions, but of recent years this custom has been abandoned, each Society being strong enough in itself to hold independent meetings.

The Eleventh General Meeting of the Meteorological Society was arranged to be held in the city of its birth on September 28-30 last, following immediately on the break-up of the meeting of the German Association—the Naturforscher und Aerzte—at Cologne. As the date of the meeting was close upon the twenty-fifth anniversary of the

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founding of the Society, it was decided to make this a special occasion for celebrating the very interesting event—the celebration taking the form of a spell of really hard work!

A large number of members attended, every quarter of the Empire being represented. In addition there came, bearing greetings from foreign countries, Vice-Director Axel Steen from Christiania, Hofrath Konkoly from Budapest, M. Teisserenc de Bort from Paris, Professor Rotch from Blue Hill Observatory, Mr. Hunt and Mr. Barton from Australia, while I had the honour of being invited by our President to act as the representative of the Royal Meteorological Society. The reception of the foreign visitors was of the most cordial character—it left nothing to be desired, and it will have a lasting effect in furthering the good relationship already existing between the various meteorological societies of the world. Speaking for myself, I cannot be otherwise than deeply gratified with the kindness extended to me, as the representative of the senior Society, by all connected with the arrangements.

Many ladies and gentlemen attended a preliminary informal gathering on the evening of the 27th, when old friendships were renewed and new ones cemented. On all sides the keenest regret was expressed at the unavoidable absence of Excelleney von Neumayer, the first President, on account of his advanced age, and the very long distance of his residence from Hamburg. (After the close of the meeting I visited the veteran meteorologist at his home at Neustadt, in the Palatinate. He was elected an Honorary Member of this Society thirty-four years ago.)

Following an early morning meeting of the officials for transacting the business of the Society, a public meeting was held in the Aula of the Wilhelmsgymnasiums at 10.30 a.m. on the 28th, with Professor Hellmann, the President, in the Chair. After extending a warm welcome to all present, thanking the Hamburg authorities for the arrangements that had been made for the visitors, and wishing success to the meeting, the President called upon Admiral Herz, the Director of the Seewarte, to convey to the Society the semi-jubilee greetings of the official Meteorological Services; upon myself to perform the same duty on behalf of the foreign societies represented; upon Professor Voller, Director of the State Physical Laboratory, on behalf of the Public Institutions of Hamburg; and upon Dr. Friederichsen, Secretary of the Geographical Society, on behalf of the scientific societies. In the absence of Professor Sresnewsky of Dorpat, Professor Köppen conveyed the greetings and best wishes of the Russian Meteorological Institute and other societies.

In reply, the President expressed the thanks of the Society for the expressions of goodwill which had come from so many quarters. It was, he said, known to only a few that the Society owed its origin to Professor Köppen, who was the first to suggest its formation. During a feeling reference to the great loss which the Society in particular, and Science generally, had sustained in the death of Professor von Bezold, the whole audience stood up. After reviewing the history of the Society and the progress of the *Meteorologische Zeitschrift*, Professor Hellmann proceeded to deliver an address on "The Dawn of Meteorology."

At the conclusion of the address, the President announced that the Society had decided upon offering a prize of 3000 marks for the best work on the observations obtained in the international investigations of

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the upper air; also, that the Council had elected as honorary members of the Society, Dr. Shaw, Professor Rotch, and MM. Angot and Teisserenc de Bort.

All the subsequent meetings were held in the great lecture theatre of the Laboratory buildings. That it was fully intended to celebrate the Society's coming of age, as one might say, in hard work was evidenced in the fact that the programme contained a list of twenty-eight papers, and of these twenty-five were actually read and discussed. To get through such a task it was necessary to keep steadily at work from 9 a.m. to noon, and from 1 p.m. to 6 p.m. The papers were classified, those on General Meteorology occupying the afternoon meeting of the 28th, the authors being Vice-Director Steen, Dr. Jensen, and Professors Schubert and Köppen. Nearly the whole of the 29th was devoted to the Meteorology of the Upper Air, the contributors being M. Teisserenc de Bort, Professors Rotch, Hergesell, Erk, Schreiber and Möller, and Drs. Wegener, Schmauss and Coym, while Professors Börnstein and Grossmann brought the day to a close with papers on Weather Reports. It had been the intention to hold only a forenoon meeting on the 30th, but to complete the task which had been set an afternoon sitting was necessary, the day being given up to Weather Reports, General Meteorology, and Atmospheric Electricity, papers being read by Professors Köppen, Assmann, Kassner, Erk and Lüdeling, and Drs. Polis, Steffens and Less.

This bare list of the names of the authors is sufficient to indicate that the contributions were of the highest order. From such a "feast of reason" it is extremely difficult to make a selection for special mention, but I might be permitted to refer briefly to two communications which could be described as of an immediately practical character.

The enlistment of wireless telegraphy as a powerful aid in weather forecasting is of the utmost importance to Meteorological Science, and more especially to ourselves, for the British Isles have hitherto had the impenetrably mysterious Atlantic to windward.

During the past summer Dr. Polis, Director of the Aachen Meteorological Observatory, made a special voyage to and from New York, on the Hamburg-Amerika Liner *Kaiserin Augusta Victoria*, with the object of studying the practicability of collecting ocean weather observations by means of wireless telegraphy. The result was a series of daily maps prepared from the reports thus received, and thrown on the screen they formed one of the most interesting exhibits at the meeting. Day by day the ship was the centre of a network of observers within a radius of from 350 to 500 miles. A suggestion was made that, for Weather Report purposes, the observations on board wireless vessels beyond the reach of direct communication with coast stations should be collected by other ships nearer land. Even if such far-distant observations arrived in London, Paris, Hamburg, or other centres, too late for use with, say, the morning report, they would still be of value in the preparation of later reports. Dr. Polis thought that Germany might issue two reports daily, instead of the morning one only as at present. So important was the report by Dr. Polis regarded that an official investigation of the subject has been undertaken, and the Council of the Seewarte has already taken some steps to organise a practical test before finally deciding what it is possible to accomplish with the means at present available.

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The paper by Professor Börnstein on the German Public Weather Services described the remarkable development of the scheme for providing the public with the earliest possible official information relating to the weather. From the Seewarte is issued the complete lithographed daily report, but late in the afternoon, so that when it reaches subscribers the information is a day old. By this time it has been felt that immediate practical interest in them has evaporated—they belong more to the past than to the present. Three years ago the question of how to bring the reports to the immediate notice of the public was under discussion, and the German Government, with that unbounded liberality which characterises all its doings when the advancement of science is desired, at once supplied the means for carrying out the scheme proposed. The Empire was divided into about a dozen districts, each having its central distributing station, and in a few cases a branch station. Berlin, Hamburg, Aachen, Frankfort, Weilburg, etc., are centres for the prompt dissemination of daily meteorological reports through their surrounding districts.

To render the scheme at all practicable it was absolutely necessary to make liberal use of the telegraph service, that there should be no delay in the transmission of messages, and that the cost should be merely nominal. These concessions have been willingly granted, the official meteorological telegrams having priority on the wires, and the cost of transmission is only one-sixth that of the public rate!

At 8 a.m., Middle European Time (7 a.m. Greenwich), observations are taken over practically the whole of Europe, and from many scores of stations reports are immediately telegraphed to the Deutsche Seewarte, at Hamburg, for the preparation of the more elaborate Official Weather Report. To save time, a special staff from the Seewarte attends at the Central Telegraph Office to receive the telegrams, and to sort out a considerable number of representative ones—from Western Ireland and Iceland to Western Russia, and from Northern Norway to Sardinia—which are used to prepare a chart showing the distribution of pressure, the winds, the temperature, and the weather over the region. Such is the remarkable rapidity with which the telegrams pour in, that by 9.15 a.m.—that is, only 75 minutes from the time of observation over an area of more than 3,000,000 square miles—the chart, with the addition of a general summary of the conditions, is nearly ready for printing! In fact, there is so much information available that at 9.15 a.m., to the minute, a long message containing reports from more than fifty of the selected stations is despatched to the various centres and to several newspapers—forty-five telegrams in all—to enable the local authorities to proceed with the preparation of a similar weather map to that being hurried on at Hamburg. By 9.30 a.m. the Hamburg report is completed, and copies are being struck off for distribution amongst a thousand subscribers in the district. At the meetings of the Society copies were delivered each morning before 9.45. I have here one of several copies actually printed before 9.30 a.m. on October 2.

At 9.45 a.m. another and final telegram, containing reports received in the last half hour, is despatched to the district centres for the completion of the work. Not a moment is lost anywhere. For instance, having watched the progress of the work at the head centre, Hamburg, I

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decided on proceeding to Aachen to witness another stage. There I found the long report, timed 9.15 a.m. from Hamburg, already being charted by 9.30 a.m.; the additional 9.45 a.m. message from Hamburg was signalled on the instrument at 9.55 a.m., and ten minutes later the map, remarks, and extra local reports had been completed, and soon a cyclist was speeding away with copies for distribution, the district having 1100 subscribers in summer, 600 in winter. An endeavour is made to have the report in the hands of the public in the course of the forenoon; but Berlin issues a more complete report with much additional information, so that it does not appear until about noon. The great advantage of these reports is that they exhibit the conditions of to-day, and not those of yesterday. Each centre is at liberty to add to the reports received from the Seewarte, and it will be seen from the copies exhibited that advantage is taken of this liberty to give much information of local and of other interests—reports from high level stations, kite observations at Lindenberg and Friedrichshafen, accounts of balloon flights, local weather and river observations, etc.

There are now between 7000 and 8000 subscribers for these reports. They are studied in the universities, in agricultural and other colleges, in many of the ordinary schools, exhibited inside and outside numerous public institutions, at health resorts, at various post offices, railway stations, and hotels; with the result that, after an experience of less than three years, the general public are found to be taking an intelligent interest in them.

As to the cost—well, any one can go into a post office and order the daily weather reports for a month or for two or three months, and the payment demanded amounts to the sum of *one farthing per day, including delivery by post!*

To the foregoing account of the solid work which we got through, I will only add that agreeable relaxation was provided for us every evening. On the 28th Dr. Burchard, the Burgomaster, on behalf of the Senate of Hamburg, held a Reception at the Rathaus. In honour of the foreign guests their consular representatives were invited, and the British Consul-General, Sir William Ward, C.V.O., consequently attended the Reception. Next evening there was a largely attended dinner at the Hamburger Hof; and on the 30th, members were taken on a steamer provided by the Hamburg-Amerika Company round the extensive harbour, and on a run down the Elbe, then returning to inspect the Company's 10,000 ton mail steamer, the *König Wilhelm II.* On October 1, the Seewarte and other establishments were thrown open to the visitors; and late in the day many members proceeded to Gross-Borstel to inspect the official kite-flying station, and to witness the ascent of an unmanned balloon, with self-registering instruments suspended below, the method employed for recording the position of the balloon, until at last it disappeared in the darkness of night, being watched with the greatest interest. A dinner given by Professor Köppen brought a most successful meeting to a close.

After the reading of the above Report:—

The President (Dr. H. R. Mill) said they were much indebted for the able manner in which Mr. Harries had represented the Society, and also for the

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extremely interesting account he had given of the proceedings at Hamburg. He wished to express to Mr. Harries their hearty thanks for his kindness both in going to Hamburg on behalf of the Society, and coming there that evening to read his Report; and he would inform Dr. Hellmann of the interest with which the Report had been received, and assure him of the hearty goodwill of this Society to the sister society in Germany.

Oceanography and Climatology.

At the recent International Geographical Congress at Geneva, Prof. O. Pettersson of Stockholm and Prof. G. Schott of Hamburg contributed papers, explaining the necessity of commencing as soon as practicable an exploration of the Atlantic Ocean on an international basis with respect to its physical and biological conditions. The substance of the two papers was given in an article in the *Geographical Journal* for January 1909, from which we extract the following:—

1. "In regard to Oceanography and Climatology. All deep-sea expeditions of later years have started from Europe to the southward, and have occupied themselves principally with the eastern half of the South Atlantic. But about the interesting and complicated conditions of the western half of the North Atlantic Ocean, within the boundaries of the Gulf Stream and the Labrador Current, no systematic deep-sea research has been made with modern instruments and by modern methods since the days of the *Challenger* expedition, excepting some observations of the U.S. s.s. *Albatross*. There can hardly be any doubt that what is going on in the western part of the ocean will furnish a key to what is going on in the eastern part, that is to say, on the European side.

"We know nearly nothing about the magnitude and laws of the changing variations of the Atlantic currents in regard to strength or temperature. In this respect a foundation ought to be laid for all later investigations. The non-periodic changes in the temperature of these currents, principally those of the Gulf Stream, are of vast importance for Western Europe. Their causes must be looked for in the Gulf Stream itself. Hence the necessity of following it up to its origin further westward. By careful investigations of different scientists it appears very probable that these non-periodical changes in the Atlantic temperature have a deep and far-reaching influence, not only upon the weather, but also upon the vegetation and the harvest results of Europe. A study of the primary causes of these changes is thus not only of purely scientific, but also of great practical, interest.

2. "In regard to Meteorology and Aërology, oceanographical expeditions upon the Atlantic Ocean will open up regions hitherto nearly altogether closed, namely, the investigation of the physical conditions of the higher strata of the atmosphere above this ocean. In this respect the forties and fifties of latitude seem specially important for Europe, because the highways of barometric depressions run here about west–east and south-west–north-west. It is mainly the direction and frequency of these great atmospheric whirls which decide the character of the weather in European countries. These oceanographical and meteorological factors are so closely interwoven that it is at present yet impossible to say what is cause and what is effect."

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INVESTIGATION OF THE ELECTRICAL STATE OF THE UPPER ATMOSPHERE, MADE AT THE HOWARD ESTATE OBSERVATORY, GLOSSOP.

By W. MAKOWER, MARGARET WHITE, and E. MARSDEN.
Communicated by J. E. Petavel, F.R.S., F.R.Met.Soc.

[Read November 18, 1908.]

As is well known, there exists under normal atmospheric conditions a potential gradient in the atmosphere surrounding the earth. The earth being negatively charged with respect to the air a continuous electric current flows from upper atmosphere to earth. The magnitude of this current has been estimated at $2{\cdot}2 \times 10^{-16}$ amperes and $2{\cdot}4 \times 10^{-16}$ amperes per square centimetre of the ground by Mr. C. T. R. Wilson, F.R.S.,[1] and H. Gerdien [2] respectively. It follows, therefore, that a kite attached to an earth-connected wire will tend to assume the potential of the air surrounding it, and an electric current will flow continuously down the wire to earth through the winding machine to which the wire is attached. The experiments to be described were undertaken with a view to determining the magnitude of this current when the kite was at different heights above the ground. If, however, the kite is insulated from the earth, it will assume the potential of the air surrounding it, and the potential will depend on its height above the earth. Some experiments were also made to ascertain the potential of the air at different heights above the ground, by insulating the kite and determining its potential, but these preliminary observations were discontinued on account of the difficulty of satisfactorily insulating the kite when dealing with the large differences of potential to be measured when the kite was at great heights above the ground. We hope shortly to overcome these difficulties, and to carry out experiments to measure the difference of potential between the ground and an insulated kite at various heights.

In the earlier experiments the wire carrying the kite was detached from the winding drum before beginning measurements, and fixed to a stout piece of ebonite securely attached to the ground. An insulated wire was taken from the lower end of the kite wire to one terminal of a galvanometer, the other terminal being connected to earth. Thus the current passing down the kite wire to earth passed through the galvanometer. By calibrating the scale of the galvanometer, the current flowing down the kite wire could be deduced.

The galvanometer was of the moving coil type and quite dead-beat, so that even rapid variations in the current could be detected and recorded. The sensitiveness was such that a current of 10^{-8} amperes could be detected.

In order to make measurements of the current when the kite was at different heights above the ground, about a mile of steel wire was wound on a drum in lengths varying from 600 ft. to 2000 ft., the lower

[1] C. T. R. Wilson, *Proceedings Royal Society*, vol. **80**, p. 537.
[2] Gerdien, *Physikalische Zeitschrift*, vol. **6**, 1905.

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extremity of the wire in each case being fastened to the ebonite insulator.

As in these experiments the kite carried no recording barometer, the altitude of the kite above the ground was estimated by recording the length of wire out and the angle of the kite above the horizon. Although this method of determining the height of the kite above the ground is very rough, it served sufficiently well for these experiments.

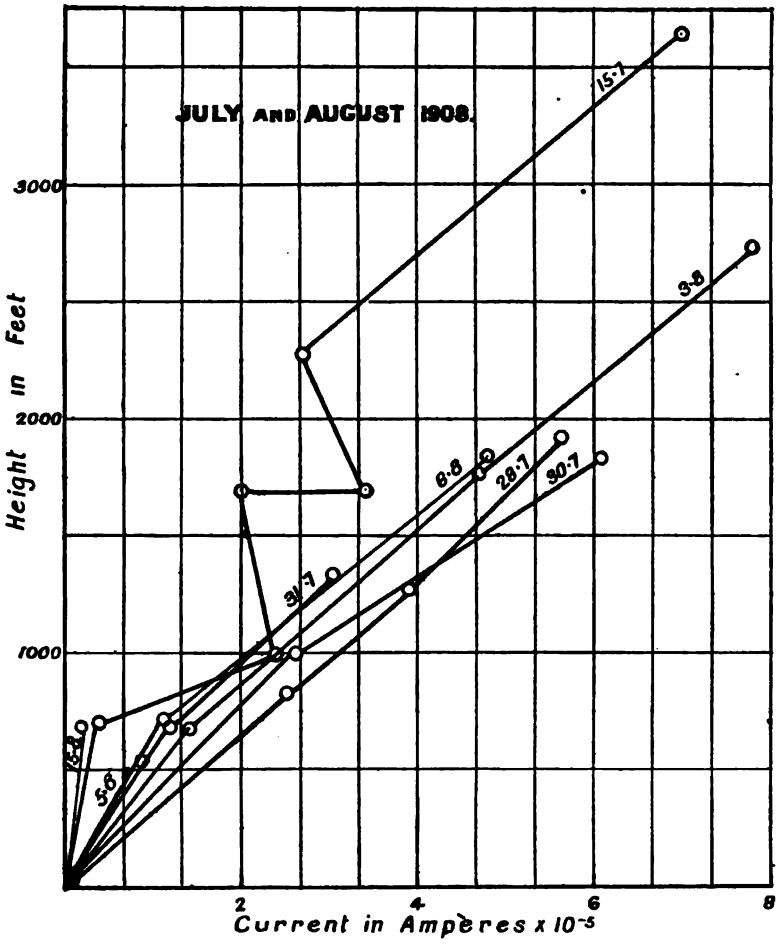


FIG. 1.—Current Height Curves—1st method. The numbers on the curves refer to the dates.

The currents obtained when the kite was at different heights above the ground are shown in Fig. 1.

It will be seen that the current varied in a somewhat irregular manner with the heights above the ground, and was different on different days for the same height.

Each point of the curves represents the mean current passing through the galvanometer while the observations were in progress, for, as might

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have been expected, the current varied considerably as the kite rose and fell, the fluctuations being most noticeable on windy or gusty days.

At the greater heights the currents were so large that it was found necessary to shunt the galvanometer with low resistances, in order to get readable deflections. As the resistance of the kite wire itself was known (being equal to ·0925 ohm per foot) it was thought that it might be

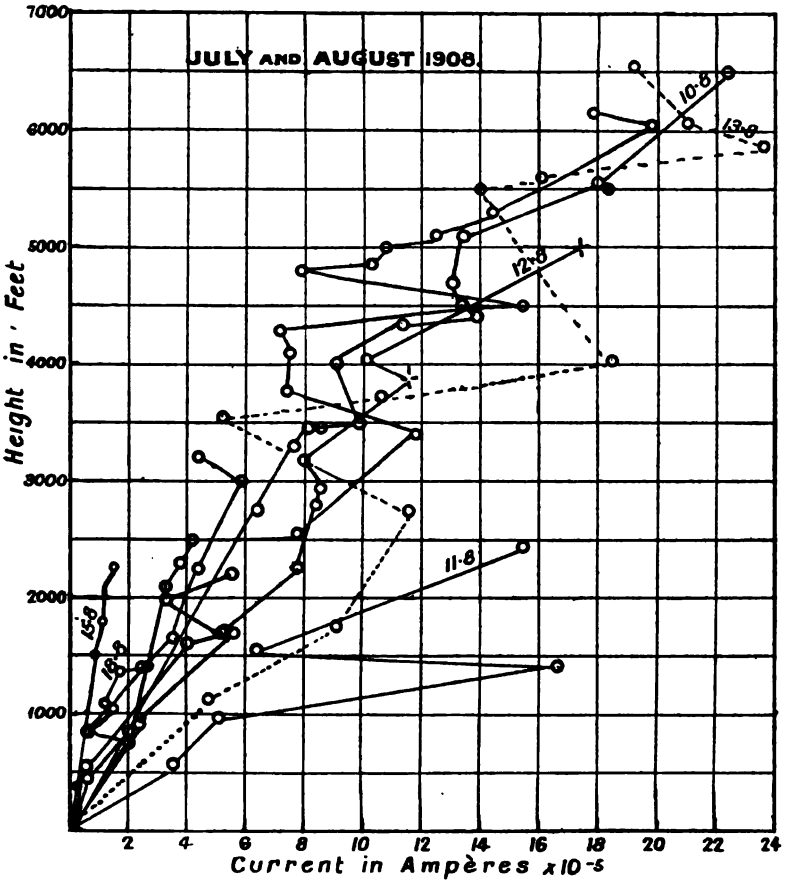


FIG. 2.—Current Height Curves—2nd Method. The numbers on the curves refer to the dates.

possible to make use of a length of the kite wire to shunt the galvanometer, and so take readings during the ordinary kite flights, which were daily in progress, and thus avoid detaching the kite from the winding machine.[1] For this purpose one terminal of the galvanometer was connected to the winding-machine which was earthed, the other terminal being connected to a point along the wire 67½ ft. distant from the machine. In this way the galvanometer was shunted by a resistance of

[1] We are indebted to Mr. A. J. Makower for suggesting this method and for some assistance in carrying out the experiments.

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6·24 ohms, and, with a knowledge of the resistance of the galvanometer and the leads used, it was possible to calculate the fraction of the current flowing down the kite wire, which was conveyed to earth through the galvanometer. From these observations the current flowing from the kite to earth could easily be calculated.

The advantages of this method of working are so obvious as to merely need mentioning. In the first place, it was possible to take observations during the daily ascents which were made at Glossop, and so obtain information at greater heights than was possible when flying special kites in the manner described above.

In the second place, the kite carried a recording barometer, from which the heights of the kite above the ground at any instant could be determined with greater precision than in the previous measurements.

On the other hand, the method was subject to the disadvantage that the electrical measurements were now subject to errors due to faulty contacts, or other uncertain resistances in the galvanometer circuit. Considerable care was exercised to reduce errors due to this cause, and it was thought that the advantages to be gained by the use of this method outweighed the inconsiderable loss of accuracy in the electrical measurements.

Observations were obtained in this way up to heights of 6500 ft. above the ground, and the results obtained are shown in Fig. 2.

The general features of the results are the same as those obtained in the previous experiments, and it is again noticeable that the current passing down the kite wire at any height exhibits considerable fluctuations.

Although the cause of these irregularities in the current is not altogether clear, it seems certain that they are in part due to changes in wind velocity. In general a high wind produced at a given altitude an abnormally high value of the current flowing down the wire. Whether the action of the wind is to be accounted for by the greater volume of air which passes in a given time over the sails of the kite, so giving a greater volume of air from which electricity is collected, or whether the action of the wind is to be attributed to electrification by friction, it is difficult to say; but it will be seen from Fig. 3 that the velocity of the wind does play an important part in determining the current flowing down the kite wire.

In Fig. 3 the points connected by the dotted line show the values of the current on different days at heights 500, 1000, 2000, 3000, 4000, 5000, 6000 ft. above the ground respectively. The points connected by the continuous line give the wind velocities as recorded by the wind gauge on the kite at the times of observing the current flowing down the kite wire.

It will be seen that in general a high value of the current corresponds with a high wind velocity, and a low wind with a low value of the current, although it cannot be claimed that the correspondence is complete. The general nature of the results would seem to indicate that the wind is an important factor, though not the only one, which causes the large fluctuations from day to day in the value of the current flowing to earth. In further confirmation it may be added that observations made with a captive balloon in very calm weather gave abnormally low values for the current.

A general summary of the currents obtained on the different days is

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shown in the accompanying table (p. 12). Numbers are given at each successive 250 ft. above the ground, and represent the actual readings obtained at the various heights, or at the nearest height in case an observation was not made exactly at a multiple of 250 ft.

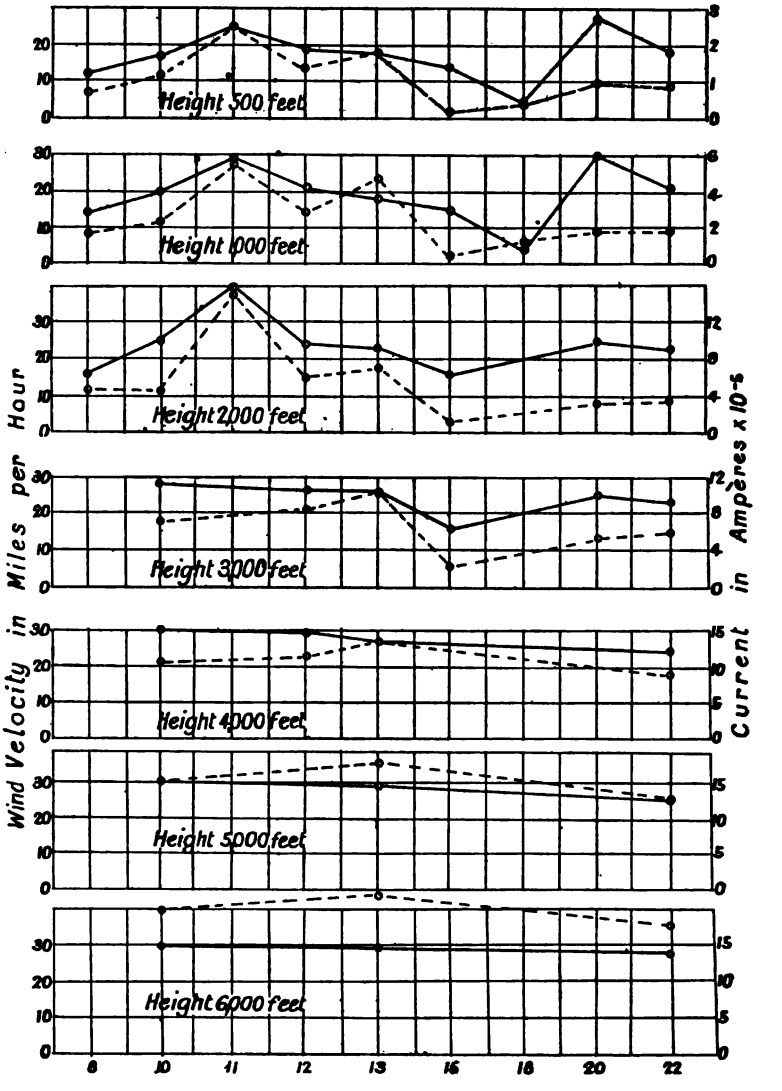


FIG. 3.

We take this opportunity of expressing our sense of obligation to Professor J. E. Petavel, F.R.S., for valuable suggestions with regard to the work, and to Mr. T. V. Pring for his courtesy in allowing us to take advantage of the daily kite ascents.

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1908.	Height in Feet above Ground Level.																							Remarks.
	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	5750	6000	6250	6500	
July 15		4·1	24			27		27																		First Method
,, 28		24		39			57																			,, ,,
,, 30			27			60																				,, ,,
,, 31		12		28																						,, ,,
Aug. 3		13				47				78																,, ,
,, 5	9·0																									,, ,,
,, 6		11				48																				,, ,,
,, 8	6·0				41	53	35	55																		Second Method
,, 10										64		77			92	132	130	131	134		179				224	,, ,,
,, 11	37		50		85				155																	,, ,, Strong Wind
,, 12		11	25			55		78		84	86	80	86	137*	108	187*	173*									,, ,, *Two Kites
,, 13			46			91				116			52	106	185						179	237	202		192	
,, 15		1·8			9·4	11·4	13	15																		,, ,, Light Wind
,, 18	2·3	5·8	13	17	28																					,, ,, Captive Balloon
,, 20		14				36	47	75			65	43	159*			178*										,, ,, *Two Kites
,, 21	6·6	9·6																								
,, 22		16·5			25		33	38	60				118	74*	75*	72*	155*	91*	118*	144*	180*		198*	180*		,, ,, *Two Kites
Average	12·2	11·2	31	28	38	48	37	48	107	86	76	67	104	106	115	142	153	111	126	144	179	237	200	180	208	

Current in Millionths of an Ampere.

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DISCUSSION.

Mr. W. H. DINES said he thought the results obtained were very interesting. He regretted the absence of the authors of the paper, as he would have liked to ask several questions. The point of interest was to get the potential of the atmosphere at various heights. He did not think the magnitude of the current conveyed a great amount of information. The length and resistance of the wire out had not apparently been taken into account; this must reduce the current, possibly from 10 to 20 per cent. Another point was—how much of the electricity was collected by the wire, and how much by the kite? He did not know from where the current came, it might be chiefly from the kite or perhaps a considerable portion might be collected by the wire.

Mr. W. W. BRYANT remarked that the wire used in these experiments seemed not to have been insulated wire, but ordinary kite wire. If this were so, there was an enormous assumption involved in the idea that the potential at the lower end of the wire would be the same as that of the air at the upper end. There would be a considerable amount of leakage on the way down the wire, especially when there was much wind. To get atmospheric electricity everything must be insulated between the collector (whether water, flame, or kite) and the galvanometer. Without such insulation, the experiment, in itself very promising, would give erroneous results.

Capt. D. WILSON-BARKER said, that if the wire were insulated, the kite only would be the collector of electricity. Insulated wire was more expensive and difficult to handle. He took these experiments to be more or less tentative, and to encourage others.

Mr. W. H. DINES remarked that they were obliged to take what they could get, and not what they would wish. Insulated wire would certainly be better, but they could not get it to a height of 6000 ft., as the wind-resistance on the insulation would prevent such a height being reached. In answer to a query as to whether the oil on the wire would serve as an efficient insulator, Mr. Dines replied he was unable to say.

Capt. D. WILSON-BARKER said that many years ago he had made experiments on board ship with insulated wire at the masthead, but had obtained no satisfactory results.

The Hon. C. S. ROLLS said he would like to know if the phenomenon commonly known as St. Elmo's fire could be accounted for. This had been observed in balloons at night-time. On two occasions it had been seen at a height of from 3000 to 5000 ft., and in a strong wind blowing above 30 miles an hour. The rigging of the balloons became covered with a kind of luminous fluid. If one rubbed one's hand against any part of the balloon it becomes luminous also. There were, however, no actual sparks, but he would be interested to know if it were possible to ignite the gas with this light. The last two occasions on which this phenomenon was observed had occurred in winter when it was snowing around the balloon, and it would hardly be called electrical weather. The fact of electricity being in the air was, of course, well known to aeronauts; when coming down rapidly, precautions had to be taken to avoid any discharge of electricity on the gas. It was advisable, in some types of balloons containing much metal, to take a piece of wire attached to some metallic part of the balloon and drop it on the ground, so as to discharge the current which might have accumulated, before deflating the balloon.

Mr. W. MAKOWER in a letter to the Secretary made the following reply:—

"In the first place I should like to express my regret that I was not present at the meeting to answer the questions raised in the discussion. In reply to Mr. Dines I would say that the resistance of the kite wire did not affect the

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results. An experiment was tried in which a megohm was placed between the kite and galvanometer without altering the magnitude of the current. Experiments are at present being undertaken to find whether the current can be reduced by much greater resistances, but as yet no results have been obtained. The question as to the relative quantities of electricity collected by the kite and wire is a difficult one to answer, but, although nothing can yet be said with certainty, it seems probable that the major part is collected by the kite. With regard to Mr. Bryant's question as to the leakage from the wire, there seems little room for errors from this cause, as there was never an appreciable difference of potential between the kite and earth. The main drop of potential was between the kite and the air surrounding it, from which the electricity was being collected.

Royal Observatory of Belgium.

M. J. Vincent has been appointed Director of the Meteorological Service of the Royal Observatory of Belgium, in succession to the late M. Albert Lancaster.

The Climate of Orkney.

Mr. Magnus Spence, in a paper in the *Journal of the Scottish Meteorological Society*, gives some interesting information on the climate of Orkney. Before examining the statistics of the subject, he says, we may be permitted, however futile some may consider the inquiry, to relate the current opinion of Orcadians who are octogenarians. If you were to ask them regarding the weather in their young days, almost without exception they would reply: "The winters were colder; snows and frost were more frequent and more severe; houses were often blocked with snow, so that people had sometimes to be dug out; lochs were so icebound that men, and even horses and carts, were known to cross them on ice; the like is never heard of now; in summer it was so warm that most of the farmers carted their peats from 2 a.m. to 10 a.m. to avoid the excessive warmth of midday." Some of this, but not all, may be explained on the assumptions that young blood registers a higher temperature than old, and that periodic reflections on unusual phenomena tend to their exaggeration. The year 1826 was unusually dry, and the crops were miserable. Captain Oman, Stenness, a reliable observer, stated, and others confirmed his statement, that from the sowing of bere, about May 12, till the crop was reaped, probably in the first week of August, there was not one shower. The crop was too poor in most cases to cut, and had to be pulled up by the roots.

After discussing the available statistics, Mr. Spence says: "In conclusion, the climate of Orkney is very much that of the east coast of Scotland. Its extremes of temperature are not so great. Its rainfall is slightly higher. The growth of vegetation is often greatly retarded in spring, considerably more so than on the mainland of Scotland. During April, May, and June, till Midsummer Day, spells of cold weather with North wind set in and prevent the progress natural to the season. Then gales, as those of 1890 and 1907, wither the growing grain and check vegetable growth for at least a fortnight. After that rapid progress takes place, and heavy crops are often produced. Harvests are generally a fortnight later than in Aberdeen, but seedtime is also much later. Bere, which is much grown on land where seaweed is available, has been often sown in the third week of May, and cut in the second week of August, thus growing and ripening in eleven weeks. It has been known to do this in ten weeks, but that is unusual."

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BALLOON OBSERVATIONS AT BIRDHILL, CO. LIMERICK, DURING JULY AND AUGUST 1908.

By Capt. C. H. LEY, F.R.Met.Soc.

[Read November 18, 1908.]

Site.

The site chosen for the upper air station in Ireland was near Birdhill in the valley of the river Shannon, and some 3 miles south of Loch Derg. This site, though some 25 miles south-west of that suggested by the Kite Committee, was selected on the map as one giving a good chance for recovery of balloons in winds blowing from a Southerly or Westerly point, and at the same time as furnishing the topographical features of a broad river, flat valley and lake, and high encircling hills.

The instrument, an 8-inch special theodolite, was erected on a tree trunk, placed on the top of a small rise about 150 ft. above and ¾ mile distant from the west bank of the river, and commanded a complete view of the horizon. The party were encamped near by, utilised an empty shed for the storage of hydrogen and filling of balloons, and were assisted in every way by the owner of the farm and by Captain Twiss of Birdhill House. With this assistance and with that of the weather, which was unusually favourable for Ireland, the results on the whole were successful, and a very large percentage of long runs were obtained.

Success in this respect depends mainly on being able to seize every fleeting opportunity as it occurs, and to utilise not only the early morning and late evening hours, but also the night-time, and this can best be done by a party under canvas.

Runs.

The trajectory table (p. 24) shows a table of 25 balloons, including 7 registering balloons. Of these 1 was observed to a height of nearly 33,000 ft., 4 to over 20,000 ft., 7 to over 15,000 ft., and 4 to over 10,000 ft.

In the case of the registering balloons, owing to the disproportionately large lifting force, the subtense method described below had to be abandoned (except in the case of No. I.). Moreover, as they were usually sent up in dusk, the diameter method only proved available in the case of No. XVIII., hence 5 of these were not observed.

As regards horizontal distance several balloons were observed to 126,000 ft. (24 miles), and one to an actual range of 130,000 ft. This may be considered the practical limit of vision on an opaque balloon 2½ ft. in diameter with a 35-power telescope in a clear atmosphere.

A feature developed during the course of the experiments was the observation of balloons at night by means of naked acetylene lights. After some trouble these proved quite successful, gave long runs with less risk of being lost in small clouds, and afforded points of light which could be observed on with great accuracy. The method is described below.

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Registering Balloons.

These were sent up on the International days in July, viz., 2nd, 27th, 28th, 29th, 30th, and 31st.

The original intention was to send up one or two in addition to the

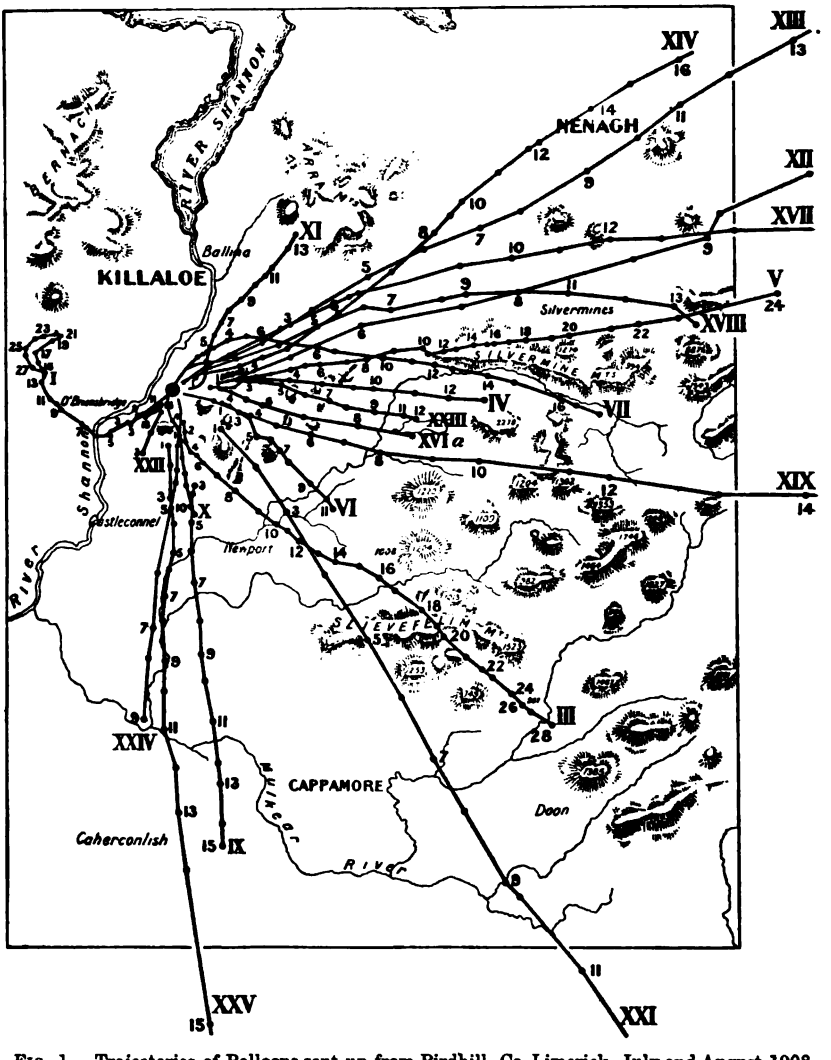


FIG. 1.—Trajectories of Balloons sent up from Birdhill, Co. Limerick, July and August 1908. The path of No. II. runs closely by the side of No. I.

above on selected occasions, with a view to dropping them in England, and arrangements were made with the Meteorological Office for telegraphic information as to the calculated probable direction and velocity of the upper current on the occasion in question. The method proposed was to then calculate the distension to be given to the balloon so as to reach the

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height desired, and to attach such a weight as would increase the time of flight to that necessary to cover the distance. This plan, however, was abandoned owing to the impossibility of getting a spare instrument. During the latter part of the International week telegraphic inquiry was made to the Meteorological Office, but the reply gave a calculated velocity of only 12 miles per hour, and direction the coast of Devonshire. This necessitated a flight of at least 12 hours (with consideration of observed lower currents), and with a heavily weighted or partially filled balloon the normal loss of gas would nullify the lifting force in a much less period of time; the attempt was therefore given up. It was, however, determined by theodolite observation that the velocity of the cirrus at an altitude of 20,000 ft. was about 25 miles an hour, and that of the lower current considerably more on the occasion in question.

During the latter part of the International week a North-west to North wind was blowing, which doubtless took the balloons a short way to the sea, and accounted for the disappointing percentage of instruments picked up.

A third would have been picked up (No. I.), except for the fact that the balloon dropped exactly in the river Shannon, and the instrument apparently had dragged on the bottom and become detached. This balloon, however, together with No. II., was sent up in exceptionally calm atmosphere, and their records were instructive, especially in view of the fact that both dropped exactly in the river, the suction effect of the river being observed and measured in the case of No. II.

The instrument records of the recovered balloons (XV. and XVIII.) were very clear, and No. XVIII. was particularly instructive because the temperature and pressure lines cross and recross one another in the isothermal regions. Mr. Dines suggests that this indicates sudden rapid changes of temperature in that region.

It appears from other records that there may be large differences of temperature in the isothermal layer over a short horizontal space at the same time.

Rate of Fall of Balloons.

In the cases of Nos. II., VII., and XVI., the balloons were observed to burst and observations were taken on the falling portions. No. II. has already been noticed. Its rate of fall was a decreasing quantity from 15,000 ft. to 6000 ft. (the average being some 60 ft. less per minute than the ascensional velocity).

The influence of the river is apparent at about this level, the velocity slowly increasing from 6000 to 2000 ft. From 2000 ft. to the river bed the velocity is much greater and the wind effect almost nil. (See table.)

The free portion of the burst balloon remained for the greater part of the fall in the field of the telescope, and was picked up alongside the other portion and the air-filled satellite the next morning. The exact position of fall had been plotted on the 1-inch map, and coincided without measurable error with the position in which the balloon was found.

In the case of No. VII. the weather conditions were threatening. The contact with the cloud burst both balloons, and the velocity of fall was an increasing one with decrease of horizontal velocity. (See table.)

In all cases the average velocity of fall was less than that of ascent.

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Effects of Surface Friction, etc.

Although it has been impossible to examine the variations in velocity in detail the general result of these observations, in conjunction with those taken at Glossop Moor in March and April, appears to be that, in nearly all conditions of wind, wave motion is noticeable.

In a general current over a flat surface this motion is more regular, but over hilly ground it is broken and confused, and there are sudden and sometimes violent gusts with occasional changes of direction, alternating with calmer intervals. On the immediate approach of hills, and just after passing them, high velocities are to be expected, also their flanks are likely places for a gust. Immediately over projecting high points or faces of a hill, the velocities appear to be subject to corresponding collapses. These effects are noticeable up to altitudes of 1500 ft. or more.

Clouds.

Immediate neighbourhood of stratus or cirrus cloud appears to cause a collapse of vertical velocity; and, generally speaking, the highest horizontal velocity of wind appears to occur below the cirrus level.

Unfortunately at Birdhill no thick cumulus or cumulo-nimbus clouds were encountered. Several balloons entered cirrus cloud at the low level of 20,000 ft.; but the cloud then was obviously not of the highest type. The difficulty of distinguishing a low cirrus cloud from the so-called "alto-stratus" is considerable, and the International nomenclature is difficult to follow in other respects.

The site, however, was favourably situated because of the frequent clearings over the Shannon Valley. The track of the Shannon and of Loch Derg by a line of blue sky bordered by thick cloud was generally noticeable at about 5 o'clock in the afternoon, and could be safely calculated upon in any but Southerly to South-westerly damp winds and cyclonic conditions. It seems possible that the effect is partly due to the downward suction of the atmosphere towards a river bed in the evening.

Pilot Balloons. Method Employed.

The method employed is similar to that known by surveyors as the subtense method; that is, obtaining the range of a known vertical bar by observation of the angle subtended by it at the instrument with an eye-piece micrometer. In this case the bar is the line joining a hydrogen balloon and a comparatively heavy air-filled balloon, and the balloons appear as discs to be bisected simultaneously by the fixed and movable wire in the diaphragm. The success of the method depends upon—(1) The ratio of the lifting force of the top balloon to the dead weight of the bottom one; (2) The distance between them; (3) Practice of the observer in getting simultaneous bisections on two moving points; (4) Accuracy of calibration of micrometer; (5) Angle of elevation; and (6) The actual height above the earth.

As regards (1) and (2), it is obvious that if the top balloon has a very large lifting force, and there is only a light weight attached, the

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motion is very unsteady and extensive swaying occurs; on the other hand, the larger the distance between the balloons the less will be the amount of angular displacement.

As regards (5), it is evident that at a great angle of elevation any angular displacement due to sway bears a larger ratio to the total angle subtended than is the case with a smaller elevation. This was observed in the case of No. I., a registering balloon with an exceptional track—and it became specially evident at angles over 45°.

The arrangement giving best results in normal conditions was as follows:—

A 24-gram, 32-gram, or 40-gram red hydrogen (Paturel) balloon filled to 75 per cent of its calculated bursting diameter (see formula), with a 180-grain Spencer red 4-gore balloon, blown out through a tube by the mouth to about 52 ins. circumference, hung about 32 ft. below it.

Displacement due to sway in the plane of sight can be detected in the telescope by rapid increases and decreases between the balloons, and can be fairly well eliminated, if necessary, by taking the average value. In a plane at an angle with the line of sight, it can be roughly estimated. With the above dimensions apparent displacement was small at a range of 3 miles, and disappeared at a range of 8 miles.

With increase of height and greater freedom from local disturbance, the system tends to become a more stable and vertical one. The difference in velocity of the wind at the top and bottom of the system is usually negligible. There is, however, a loss of vertical velocity in the above system of some 15 per cent over the case of the same hydrogen balloon flying free. Such a loss as the tabulated results show is not a serious one. 25 per cent calculated expansion should allow theoretically of a height of about 21,000 feet.

On looking at the table (p. 24), out of a total of 18 pilots, 4 only were observed to burst prematurely, and 3 of these burst at elevations of over 14,500 ft. On the other hand, 6 balloons attained heights of between 19,000 and 23,000 ft. without bursting.

It may be fairly inferred from these results that the formula used is sufficiently reliable. This formula is as follows:—

$$\text{Normal bursting diameter in inches} = \sqrt{\frac{\text{weight in grains}}{\cdot 45}}.$$

The constant actually varies from ·42 to ·48 according to pressure and unknown factors.

Method of Observation on Registering Balloons.

With registering balloons, as already mentioned, the above system is not satisfactory. Moreover, a later hour is desirable than in the case of pilots. The diameter method was therefore resorted to when possible.

Owing, however, to the usual formation of cloud after sunset during the International week, few observations on registering balloons were obtained. From 5 to 7 p.m. blue sky was the rule, and a pilot was in every case during that week sent up and observed prior to the larger balloon. With a restricted land surface no other satisfactory method could usually be employed.

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Night Balloons.

Great advantages for observation and for obtaining long runs and great heights can be obtained by using brilliant lights carried by a hydrogen balloon at night. The drawback of carrying extra weight can be made up for by using a larger pattern of hydrogen balloon, and with a few more trials doubtless very much greater heights could be attained. As it was, on two occasions on which night balloons were successfully launched, 19,500 and 22,800 ft. were obtained. A larger balloon, giving an extra 150 ft. per minute vertical velocity, would probably be seen to 30,000 ft. with ease in a clear sky, and there seems no reason why with larger acetylene balloons giving greater pressure of gas and more efficient burners, a large pattern of pilot should not be observed to even 40,000 ft. elevation, though the important matter of expense would begin to press unduly.

Another interesting feature of these balloons is the comparison of night velocities with day velocities, and the heights of clouds at night.

In the two cases of Nos. XII. and XXV., the velocities ran lower after the first 2000 or 3000 ft. than was the case with a preceding or following day pilot. The height of the same bank of cirrus cloud was 1000 ft. less at night in the case of No. XII. than in the case of No. XIII. at 6·30 a.m. the next morning, though the difference is perhaps too slight to be of any import.

The observations, so long as the illuminations of the field permitted of use of the micrometer without drawing the balloon lights, were of great accuracy, owing to the extreme steadiness of the system, and the absolute points presented for bisection. The great drawbacks, however, are the time and trouble necessary to fill the acetylene balloons, adjust burners, and attach the system safely and satisfactorily to the hydrogen balloon. The highly inflammable nature of acetylene renders ordinary lamps unsafe, if close to the generator or balloons; hence filling, tying up, etc., at night, troublesome enough with artificial light, is rendered difficult without Davy lamps. When the system is launched it is, however, safe.

A rough sketch of the arrangements is shown in Fig. 2, which explains details.

In windy weather each balloon has to be carried by one man, and two others are required for simultaneous lighting, and the business becomes difficult, if not dangerous.

In a light breeze the following system proved best for two men, assuming the three balloons filled and the two acetylene balloons connected with burners adjusted:—

(1) The hydrogen balloon, having a 30-foot thread attached with two loops at the end, is carried from the shed and hooked by one of the loops to a nail, or hook in a gate or post at the site selected. This site should not be more than 100 yards from the filling shed if possible.

(2) The two acetylene balloons are carried out to the site, and the top one is fastened to the free loop of the hydrogen balloon thread.

(3) The acetylene burners and their joints and attachments are finally quickly examined for leak, and the threads kept stretched.

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(4) At a given word both burner covers are undone, and, when ready, at another signal both burners are lighted by fusee.

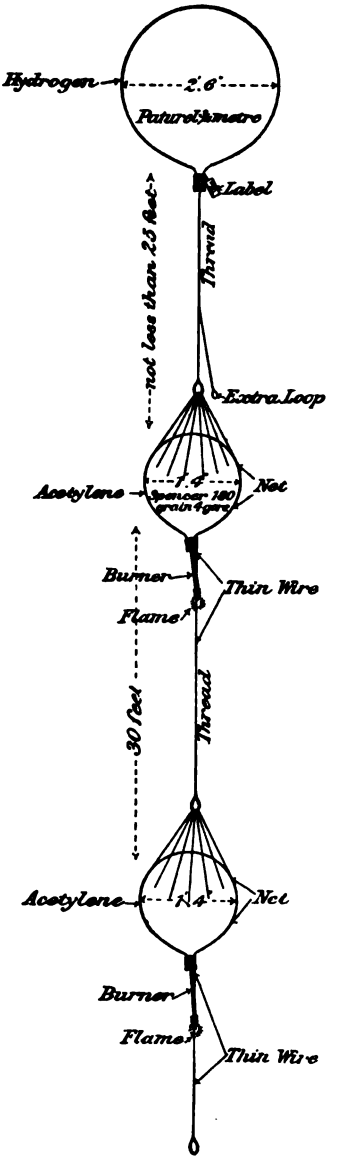


FIG. 2.—Night Balloons.

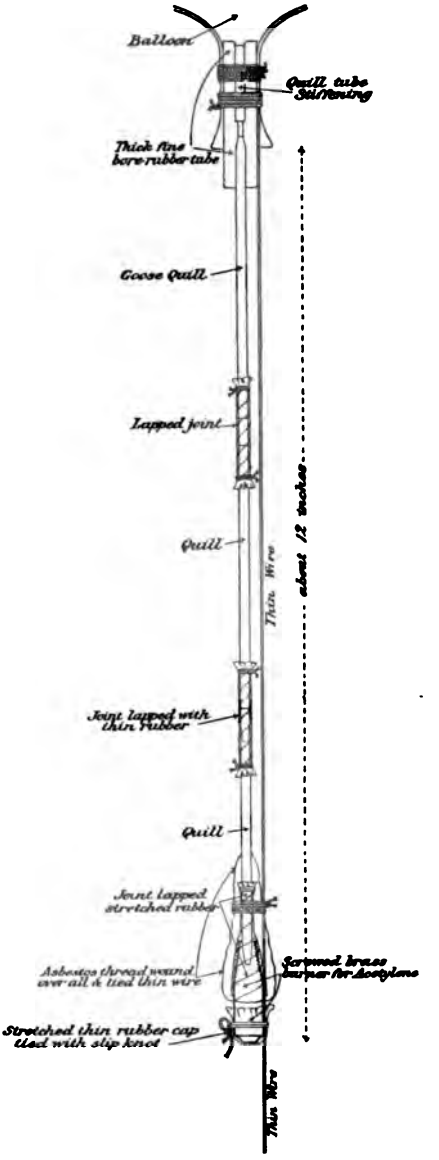


FIG. 3.—Burner—Weight complete, without balloon, about 130 grains.

(5) The man at the lower balloon holds the free end of the wire, keeping a slight tension on the system, whilst the observer at No. 1 releases the loop of the hydrogen balloon thread from the hook, and

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gives the word "Let go!" directly the first acetylene balloon begins to rise.

Care must be taken in selection of a site that there is free space in the direction to which the wind is blowing, with no house or rickyard within reasonable proximity; that in lighting, the match flame does not approach any portion of the balloon; and that the ground near the acetylene balloons is open and free from thorns or sharp projections.

The lights being visible by eye for over 8 miles, and clearly distinguishable from stars, there is ample time to walk to the observation post, even if some distance away at the top of a hill.

Solution of Heights and Horizontal Distances.

A tacheometrical slide rule is necessary for plotting the results—the formula being:

$$\left.\begin{aligned} \text{H.} &= \frac{206265\ a\ sm\ \alpha\ cos\ \alpha}{\beta} \\ \text{H.D.} &= \frac{206265\ a\ cos\ \delta}{\beta} \end{aligned}\right\} \begin{array}{l}\text{where } a = \text{distance from centre to centre in feet.} \\ \alpha = \text{angle of elevation.} \\ \beta = \text{reduced micrometer reading (seconds).}\end{array}$$

$$\left.\begin{aligned} \text{H.} &= \frac{206265\ a\ sm\ \alpha\ cos\ \alpha}{\beta} \\ \text{H.D.} &= \frac{206265\ a\ cos\ \delta}{\beta} \end{aligned}\right\} \begin{array}{l}\text{H.} = \text{height in feet.} \\ \text{H.D.} = \text{horizontal distance.}\end{array}$$

No correction for expansion is necessary.

α is read to minutes; β to decimals of micro-divisions; horizontal angle to 10 minutes.

EXPLANATORY NOTES ON THE TABLES (pp. 24-27).

Tables show—

1. Number of balloon.
2. Date.
3. Time.
4. Diameter in feet.
5. Diameter of satellite.
6. Distances apart of feet, centre to centre.
7. Free lift in grains.
8. Observations—Height in feet (above instrument).
9. „ Vertical velocity in feet per minute (previous interval).
10. „ Horizontal velocity in miles per hour (previous interval).
11. Average vertical velocity (feet per minute) over run.

A. Denotes an acetylene-filled balloon, if satellite.

D. Denotes observation by diameter method.

Height of station 218 feet above sea-level.

Figures in *italics* are approximate only.

REMARKS ON THE OBSERVATIONS

I. Registering Balloon. Picked up floating in Shannon, near Castleconnell, at 10 p.m.

II. Top balloon burst at 15,500 ft. After moving to 3, balloon is nearly stationary to 8. From 8 it moves back toward starting-point to 11; 11 to 13, returns to south-west; 13 to 16, again returns to north-east; 16 to 24, back to river.

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After bursting at 14, observations on satellite and rag of balloon. The rag of the other portion blown off was free, but crossed and recrossed the field of telescope during fall, and was picked up within a few yards of the satellite.

Balloons I. and II. show strong suction to river bed in lower atmosphere.

V. Picked up at Donaghmore, Queen's Co., 37 miles, on bearing 77°.

VI. After 11, balloon obscured by overcast stratus.

VII. Both balloons burst at cloud 16,700 ft. Observations 20 to 28 made on two rags. Clear morning, rapidly clouding over with cirrus and high stratus; rain began at 9 a.m. Note increasing velocity of fall.

IX. Balloon entered cloud after 9620 ft.

X. Balloon entered cloud after 6150 ft. Picked up on July 23rd at Brittas, 11¼ miles, bearing 168°.

XI. Balloon entered cloud after 7430 ft. Picked up near Birr, 33 miles north-west.

XII. Night pilot balloon with two acetylene lights. Lifting force only approximate. Disappeared in cloud at 10.5 p.m. at range 124,500-126,000 ft. Note gust at 9 to 10.

XIII. Compare previous balloon. Disappeared in cirrus bank, range 126,500-130,800 ft. Compare high velocities beyond 10.

XIV. Balloon burst after 16. Picked up at Shinrone, at 28 miles bearing 56°, 12 miles after bursting point. Note increasing velocities at 6; drop at 13 to 14 and high velocity 14 to 16.

XV. Registering balloon. Picked up at Mount Leinster, Co. Wexford, 57 miles east by north, on August 7th. Observations not plotted as velocities obtained by previous pilot.

XVI. (7 p.m.) Balloon burst at 8. Observations at 9 on one balloon and rag of other. Note high velocity 8 to 9.

XVI. (11.44 p.m.) Registering balloon carrying acetylene light. No observations obtainable.

XVII. Low cirrus above 20,000 ft. Strong variable wind. Note large increase at 4, and drop at 6 to 7 and at cirrus level. Disappeared at range 126,200-128,000 ft.

XVIII. Registering balloon, picked up 67 miles east.

XIX. Cloud at 17,700 ft. High velocity wind above 12, dropping off at level of high stratus.

XX. Registering balloon, no observations obtainable.

XXI. (5.30 p.m.) High stratus above 17,000 ft. Steadily increasing wind up to very high gust at 6 to 7, decreasing to 11; strong and gusty beyond. Disappeared in cloud, range 117,900-120,000 ft. Picked up at Cahir, Co. Tipperary, 25 miles, 141°, on August 7th.

XXI. (8.21 p.m.) Registering balloon, disappeared in low cloud.

XXII. Registering balloon, disappeared in cloud. [This balloon was seen some months later at the top of a tree in the neighbourhood of Fermoy, Co. Cork, 45 miles south by east. Mr. Dines reports that it just reached the isothermal layer.—EDITORS.]

XXIII. Steady breeze to 9 with decrease of vertical velocity. Picked up near Kilkenny, 52 miles east by south.

XXIV. Highest velocity 6 to 8. Picked up at Kilmallock, 27 miles south by west, on August 7th.

XXV. Night pilot with two acetylene lights. Clear sky. Visible by unaided eye to 11, range 45,400-47,300 ft. Disappeared at 12.12 a.m., range 117,000-119,000 ft.

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TRAJECTORY TABLE OF BALLOONS SENT UP FROM BIRDHILL, CO. LIMERICK, JULY AND AUGUST 1908.

No. of Balloon	I.	II.	III.	IV.	V.	VI.	VII.
Date	July ?	July ?	July 4	July ?	July 11	July ?	July 15
Time	8.6 P.M.	7.50 P.M.	7.27 P.M.	8.50 P.M.	6.53 P.M.	7.19 P.M.	6 A.M.
Balloon Diameter	3·58	2·38	2·2	2·17	2·0	1·97	2·5
Satellite Diameter	1·44	1·44	1·45	1·39	1·42	1·32	1·67
Distance apart	32·7	41·0	31·8	30·8	31·9	31·6	32·1
Free Lift	...	...	...	2000	1479	?	2547

Observations.	Height in ft.	Velocity. Vertical ft. per min.	Velocity. Horizontal miles per hr.	Height in ft.	Velocity. Vertical ft. per min.	Velocity. Horizontal miles per hr.	Height in ft.	Velocity. Vertical ft. per min.	Velocity. Horizontal miles per hr.	Height in ft.	Velocity. Vertical ft. per min.	Velocity. Horizontal miles per hr.	Height in ft.	Velocity. Vertical ft. per min.	Velocity. Horizontal miles per hr.	Height in ft.	Velocity. Vertical ft. per min.	Velocity. Horizontal miles per hr.
1	...	...	...	...	...	...	1,660	479	15·3	1,637	460	13·5	2,040	192	14·1	1,158	384	23·2	...	...	...
2	3,680	565	13·1	...	...	...	1,980	218	11·3	1,990	458	17·0	2,460	365	22·2	1,300	128	12·4	...	...	...
3	4,590	558	9·6	4,740	460	8·0	2,690	582	11·3	2,446	380	9·5	2,850	371	22·1	1,456	188	21·2	3,016	571	16·4
4	5,200	530	12·3	5,650	605	...	3,250	409	12·4	3,315	395	5·7	3,360	411	26·2	1,600	144	19·9	3,658	300	12·4
5	6,440	455	1·8	6,130	300	...	3,590	276	8·3	4,625	457	6·7	3,765	450	25·2	1,735	120	25·3	4,410	526	21·4
6	8,760	584	7·4	7,190	480	...	4,180	401	8·8	5,290	368	17·5	4,230	435	19·7	1,895	130	18·0	4,955	545	25·6
7	10,100	522	5·4	7,100	−7	...	5,030	567	19·0	5,915	447	27·2	5,100	505	24·1	2,160	193	16·4	5,790	529	27·3
8	10,730	525	13·3	8,380	658	...	6,080	401	17·4	6,690	456	30·1	5,800	500	23·0	2,560	282	14·1	6,800	148	30·3
9	12,580	437	14·2	9,410	240	2·6	7,050	400	19·7	7,290	357	28·4	6,640	461	22·7	3,350	298	17·2	7,300	270	14·5
10	13,090	452	9·7	...	...	...	8,000	730	26·2	7,650	334	27·4	7,490	708	37·0	4,390	488	17·0	9,120	475	19·8
11	13,920	754	9·2	11,000	420	1·4	8,590	421	13·8	8,770	842	48·3	7,649	78	6·0	4,250	−71	9·2	10,310	605	22·2
12	14,710	725	11·4	...	...	...	9,180	369	15·6	9,480	*450*	32·2	8,200	487	22·2	...	...	...	11,200	480	19·0
13	15,950	424	6·2	14,580	860	5·6	9,870	345	17·0	10,155	*450*	33·8	8,680	457	17·8	...	...	...	11,880	493	19·1
14	16,100	133	9·6	15,500	440	...	10,570	406	17·8	...	...	...	9,320	481	19·7	...	...	...	13,140	476	20·1
15	17,150	955	9·4	...	...	...	12,090	585	15·0	...	...	...	9,910	562	21·0	...	...	...	14,160	558	24·0
16	18,290	714	7·1	7,800	−390	1·6	12,510	234	20·2	...	...	...	10,320	300	6·4	...	...	...	15,520	950	51·0
17	19,450	500	6·9	...	...	...	13,570	678	21·2	...	...	...	11,100	513	16·1	...	...	...	15,780	208	22·6
18	20,080	130	6·6	6,520	−243	2·3	14,860	505	19·6	...	...	...	11,900	510	16·0	...	...	...	16,450	690	36·8
19	20,100	10	6·2	...	...	...	15,770	606	23·5	...	...	...	12,810	475	20·2	...	...	...	16,700	...	...
20	20,690	203	3·0	...	...	...	16,050	167	11·1	...	...	...	13,300	292	17·3	...	...	...	15,820	−248	39·3
21	21,780	895	7·5	...	...	...	17,190	606	23·6	...	...	...	14,400	485	28·0	...	...	...	...	...	...
22	23,120	510	4·0	...	...	...	17,830	426	15·9	...	...	...	15,180	366	18·9	...	...	...	14,080	−330	40·9
23	25,730	980	6·4	...	...	...	18,120	193	10·4	...	...	...	16,560	470	21·9	...	...	...	...	...	...
24	28,100	914	5·2	2,008	−296	6·7	...	...	...	...	...	...	19,480	645	34·2	...	...	...	11,190	−417	30·8
25	29,500	770	11·3	...	−570	...	19,240	726	22·4	...	...	...	...	...	...	...	...	...	...	...	...
26	30,343	*630*	6·5	...	...	..	20,020	453	13·2	...	...	...	...	...	...	...	...	...	...	...	...
27	31,433	*630*	10·8	...	...	...	21,090	640	10·6	...	...	...	...	...	...	...	...	...	...	...	...
28	32,523	*630*	10·8	...	...	...	21,990	410	16·8	...	...	...	...	...	...	...	...	...	8,478	*−350*	*20·0*
Average	...	533	...	...	445	...	...	430	...	...	448	...	...	496	...	...	275	...	...	500	...

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TRAJECTORY TABLE OF BALLOONS SENT UP FROM BIRDHILL, CO. LIMERICK, JULY AND AUGUST 1908—*Continued.*

No. of Balloon	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.
Date	...	July 18	July 20	July 21	July 22	July 23	July 27
Time	...	7 A.M.	8.5 P.M.	6.55 P.M.	9.15 P.M.	5.40 A.M.	6.25 A.M.
Balloon Diameter	...	2·18	2·31	2·17	2·5	2·0	2·07
Satellite Diameter	...	1·48	1·46	1·43	1·2 A	1·48	1·48
Distance apart	...	31·8	31·9	35·0	31·2	31·7	31·8
Free Lift	...	1698	2065	1548	1895 approx.	1300	1548

Observations.	VIII. Height in ft.	VIII. Velocity. Vertical ft. per min.	VIII. Velocity. Horizontal miles per hr.	IX. Height in ft.	IX. Velocity. Vertical ft. per min.	IX. Velocity. Horizontal miles per hr.	X. Height in ft.	X. Velocity. Vertical ft. per min.	X. Velocity. Horizontal miles per hr.	XI. Height in ft.	XI. Velocity. Vertical ft. per min.	XI. Velocity. Horizontal miles per hr.	XII. Height in ft.	XII. Velocity. Vertical ft. per min.	XII. Velocity. Horizontal miles per hr.	XIII. Height in ft.	XIII. Velocity. Vertical ft. per min.	XIII. Velocity. Horizontal miles per hr.	XIV. Height in ft.	XIV. Velocity. Vertical ft. per min.	XIV. Velocity. Horizontal miles per hr.
1	No observations (cloud).	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3,210	443	15·7	...	...	...
2		...	...	...	...	...	...	...	...	...	...	...	...	...	...	4,070	350	20·0	...	...	...
3		...	...	2,515	550	33·0	...	...	...	...	...	...	2,175	446	17·3	4,810	440	28·1	32,15	422	15·7
4		...	...	2,850	...	...	2,220	420	8·9	2,380	405	13·5	3,380	498	18·3	5,415	346	22·4	3,860	455	26·4
5		...	...	3,508	331	18·5	2,810	519	12·1	2,836	435	18·0	4,600	488	21·6	6,790	500	36·7	4,900	500	20·8
6		...	...	4,580	812	33·9	3,535	476	16·0	3,336	385	17·0	5,460	236	32·2	8,060	488	33·4	6,390	500	27·9
7		...	...	5,060	269	28·0	4,250	586	23·6	3,990	491	18·0	7,140	402	37·2	9,290	440	33·8	7,340	339	37·6
8		...	...	5,590	261	29·1	4,720	376	21·1	4,684	583	19·4	7,950	203	20·9	9,900	286	31·3	8,490	486	37·4
9		...	...	6,045	352	37·9	5,170	469	17·3	5,130	323	17·5	12,330	*400*	27·6	11,080	347	35·1	9,055	*435*	27·6
10		...	...	6,670	530	34·7	5,870	562	29·8	5,790	528	23·0	12,770	*400*	39·2	12,800	583	31·3	9,389	*435*	43·5
11		...	...	7,600	726	48·0	6,150	320	16·1	6,090	286	18·7	14,638	*400*	31·8	13,700	720	69·0	10,259	*435*	35·2
12		...	...	8,450	645	49·0	...	...	...	6,340	251	17·6	15,650	*400*	44·8	14,750	530	42·5	11,129	*435*	29·1
13		...	...	8,700	200	24·6	...	...	...	7,020	408	23·6	16,522	*400*	29·2	16,520	747	47·0	11,999	*435*	8·9
14		...	...	9,280	395	42·5	...	...	...	7,430	237	13·8	17,130	*400*	43·4	17,200	327	52·8	12,869	*435*	47·7
15		...	...	9,620	358	36·8	...	...	...	...	...	...	18,040	*400*	23·0	18,200	413	34·1	13,739	*435*	35·8
16		...	...	...	...	...	...	...	...	...	...	...	19,250	*400*	31·4	19,600	690	46·0	14,609	*435*	42·1
17		...	...	...	...	...	...	...	...	...	...	...	...	...	...	20,380	*468*	39·7	...	...	...
18		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
19		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
20		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
21		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
22		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
23		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
24		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...
25		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
26		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
27		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
28		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Average	...	...	...	...	456	...	...	425	...	...	392	...	...	*400*	...	...	453	...	...	435	...

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TRAJECTORY TABLE OF BALLOONS SENT UP FROM BIRDHILL, CO. LIMERICK, JULY AND AUGUST 1908—*Continued.*

No. of Balloon	XV.	XVI.	XVI.	XVII.	XVIII.	XIX.	XX.
Date	July 27.	July 28.	July 28.	July 29.	July 29.	July 30.	July 30.
Time	8.23 P.M.	7 P.M.	11.44 P.M.	6.15 P.M.	8 P.M.	5.50 P.M.	9.55 P.M.
Balloon Diameter	4·0	2·25	3·5	2·1	3·48	2·1	3·5
Satellite Diameter	...	1·4 A	A	1·3	...	1·4	...
Distance apart	D	34·8	...	31·5	D	34·8	...
Free Lift	6364	1857	...	1528	...	1518	5745

Observation.	XV.			XVI.			XVI.			XVII.			XVIII.			XIX.			XX.		
	Height in ft.	Velocity.		Height in ft.	Velocity.		Height in ft.	Velocity.		Height in ft.	Velocity.		Height in ft.	Velocity.		Height in ft.	Velocity.		Height in ft.	Velocity.	
		Vertical ft. per min.	Horizontal miles per hr.		Vertical ft. per min.	Horizontal miles per hr.		Vertical ft. per min.	Horizontal miles per hr.		Vertical ft. per min.	Horizontal miles per hr.		Vertical ft. per min.	Horizontal miles per hr.		Vertical ft. per min.	Horizontal miles per hr.		Vertical ft. per min.	Horizontal miles per hr.
1	Low Cloud. Registering Balloon.	...	...	...	...	...	No observations obtainable. Registering Balloon.	...	...	...	...	...	1,772	823	18·0	...	...	...	Registering Balloon. No observations obtainable.	...	...
2		...	...	...	...	...		...	...	...	...	...	2,650	765	23·2	...	...	...		...	...
3		...	...	3,380	436	7·3		...	...	...	...	...	3,760	765	29·4	1,950	377	11·6		...	...
4		...	...	4,680	485	12·3		...	...	2,290	314	13·8	5,250	742	32·5	2,760	306	22·5		...	...
5		...	...	5,440	317	9·9		...	...	4,350	865	48·3	6,690	810	36·4	3,440	335	21·3		...	...
6		...	...	6,780	433	9·6		...	...	5,290	388	36·6	7,980	574	34·2	4,710	663	28·5		...	...
7		...	...	8,850	458	13·5		...	...	5,280	...	11·0	8,290	142	18·8	5,580	490	28·7		...	...
8		...	...	11,100	*428*	14·1		...	...	6,390	467	30·6	9,910	965	47·3	6,880	658	29·4		...	...
9		...	...	9,820	− 311	20·7		...	...	7,950	770	43·1	10,480	218	14·8	7,050	82	38·6		...	...
10		...	...	...	...	...		...	...	9,040	400	29·3	12,040	*650*	56·0	7,650	225	26·0		...	...
11		...	...	...	...	...		...	...	10,190	480	30·3	13,340	*650*	38·7	9,790	665	37·6		...	...
12		...	...	...	...	...		...	...	11,390	595	38·9	14,640	*650*	43·2	11,000	460	23·4		...	...
13		...	...	...	...	...		...	...	12,550	386	24·9	15,940	*650*	38·0	11,620	286	76·5		...	...
14		...	...	...	...	...		...	...	13,870	475	40·0	16,655	*650*	39·4	12,920	514	52·0		...	...
15		...	...	...	...	...		...	...	15,540	600	40·0	...	...	...	14,620	612	63·8		...	...
16		...	...	...	...	...		...	...	18,920	735	43·8	...	...	...	15,300	313	44·0		...	...
17		...	...	...	...	...		...	...	19,750	178	54·3	...	...	...	16,550	588	49·2		...	...
18		...	...	...	...	...		...	...	20,036	*572*	21·2	...	...	...	17,530	*446*	44·0		...	...
19		...	...	...	...	...		...	...	...	...	...	...	...	...	17,700	...	...		...	...
20		...	...	...	...	...		...	...	...	...	...	...	...	...	...	...	...		...	...
21		...	...	...	...	...		...	...	...	...	...	...	...	...	...	...	...		...	...
22		...	...	...	...	...		...	...	...	...	...	...	...	...	...	...	...		...	...
23		...	...	...	...	...		...	...	...	...	...	...	...	...	...	...	...		...	...
24		...	...	...	...	...		...	...	...	...	...	...	...	...	...	...	...		...	...
25		...	...	...	...	...		...	...	...	...	...	...	...	...	...	...	...		...	...
26		...	...	...	...	...		...	...	...	...	...	...	...	...	...	...	...		...	...
27		...	...	...	...	...		...	...	...	...	...	...	...	...	...	...	...		...	...
28		...	...	...	...	...		...	...	...	...	...	...	...	...	...	...	...		...	...
Average	...	900	...	...	428	...	...	...	...	...	443	...	...	607	...	...	446	...	...	...	...

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TRAJECTORY TABLE OF BALLOONS SENT UP FROM BIRDHILL, CO. LIMERICK, JULY AND AUGUST 1908—*Continued.*

No. of Balloon	XXI.	XXI.	XXII.	XXIII.	XXIV.	XXV.
Date	July 31	July 31	Aug. 1	Aug. 3	Aug. 6	Aug. 6
Time	5.30 P.M.	8.21 P.M.	8.25 P.M.	7.5 P.M.	7.45 P.M.	11.10 P.M.
Balloon Diameter	2·1	4·0	3·9	2·15	2·0	2·5
Satellite Diameter	1·4	A	...	1·35	1·46	1·2 A
Distance apart	34·7	D	D	32·0	32·0	33·0
Free Lift	1548	7781	5555	1379	1188	?

Observation.	XXI. Height in feet.	XXI. Velocity. Vertical ft. per min.	XXI. Velocity. Horizontal miles per hr.	XXI. (2nd) Height in feet.	XXI. (2nd) Velocity. Vertical ft. per min.	XXI. (2nd) Velocity. Horizontal miles per hr.	XXII. Height in feet.	XXII. Velocity. Vertical ft. per min.	XXII. Velocity. Horizontal miles per hr.	XXIII. Height in feet.	XXIII. Velocity. Vertical ft. per min.	XXIII. Velocity. Horizontal miles per hr.	XXIV. Height in feet.	XXIV. Velocity. Vertical ft. per min.	XXIV. Velocity. Horizontal miles per hr.	XXV. Height in feet.	XXV. Velocity. Vertical ft. per min.	XXV. Velocity. Horizontal miles per hr.
1	3,800	427	10·5	Registering Balloon disappeared in low cloud.	...	...	2,800	634	...	2,130	403	12·8	2,023	358	10·4	2,645	363	11·3
2	5,410	517	25·2		...	...	4,590	484	...	3,010	510	17·8	2,980	466	6·7	3,396	326	12·8
3	6,490	383	29·2		...	...	5,590	357	...	3,700	482	13·1	4,050	432	15·1	4,390	336	17·3
4	7,590	377	38·2		...	...		...	...	4,290	372	12·5	4,660	359	12·1	5,320	275	11·2
5	8,730	422	43·5		...	...		...	...	5,050	313	14·0	5,800	500	16·5	6,800	518	15·6
6	9,570	388	47·4		...	...		...	...	6,040	379	14·6	8,150	415	17·6	7,520	310	11·3
7	10,420	694	86·0		...	...		...	...	6,730	326	18·0	9,700	423	23·0	8,280	271	15·7
8	10,650	124	49·8		...	...		...	...	7,320	300	13·3	10,570	370	19·6	9,360	375	13·0
9	12,360	627	46·3		...	...		...	...	7,940	389	27·1	12,780	*408*	17·3	11,080	380	24·0
10	12,530	104	18·1		...	...		...	...	...	...	...	...	...	...	12,140	329	14·5
11	14,340	545	43·9		...	...		...	...	9,190	500	18·5	...	...	...	13,400	485	22·3
12	16,520	658	60·0		...	...		...	...	9,720	371	11·9	...	...	...	13,950	205	22·5
13	17,160	*440*	46·3		...	...		...	...	...	...	...	...	...	...	14,950	444	27·1
14	...	...	...		...	...		...	...	...	...	...	...	...	...	15,880	228	21·4
15	...	...	...		...	...		...	...	...	...	...	...	...	...	18,560	*360*	32·5
16	...	...	...		...	...		...	...	...	...	...	...	...	...	20,200	*360*	32·4
17	...	...	...		...	...		...	...	...	...	...	...	...	...	...	...	...
18	...	...	...		...	...		...	...	...	...	...	...	...	...	21,810	*360*	36·2
19	...	...	...		...	...		...	...	...	...	...	...	...	...	22,610	*360*	...
20	...	...	...		...	...		...	...	...	...	...	...	...	...	...	...	...
21	...	...	...		...	...		...	...	...	...	...	...	...	...	...	...	...
22	...	...	...		...	...		...	...	...	...	...	...	...	...	...	...	...
23	...	...	...		...	...		...	...	...	...	...	...	...	...	...	...	...
24	...	...	...		...	...		...	...	...	...	...	...	...	...	...	...	...
25	...	...	...		...	...		...	...	...	...	...	...	...	...	...	...	...
26	...	...	...		...	...		...	...	...	...	...	...	...	...	...	...	...
27	...	...	...		...	...		...	...	...	...	...	...	...	...	...	...	...
28	...	...	...		...	...		...	...	...	...	...	...	...	...	...	...	...
Average	...	440	...	...	...	...	...	530	...	...	400	...	...	408	...	...	360	...

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Description of Methods

Day Balloons.—Hydrogen balloon: (2 ft. to 2 ft. 6 ins. diam.). Paturels 2 francs 50 centimes, 3 f. 50 c., 4 f. 50 c. used, filled to 75 per cent of bursting diameter.

Bursting diameter obtained from formula $d = \sqrt{\frac{w}{\cdot 45}}$ where d is in inches, w = weight in grains.

Lift varies with pressure and temperature, but largely with quality of gas.

Satellite: filled with mouth-piece from lungs to about 16 ins. diameter. Spencer's 9d. balloon. Hung 30 ft. to 35 ft. below. Hydrogen balloon—weight when filled = about 190 grains.

Theodolite: calibrated up to 500 seconds on 1 inch bull's-eyes 3000 ft. distant at calculated vertical intervals.

Micrometer readings to ·15 sec. Vertical arc to 1 min. Horizontal arc to 10 min. Time by stop watch to 1 sec.

The pendulum motion with above sizes and lengths is slight after 15,000 ft., and cannot be observed above 40,000 ft. range. With registering balloons the lifting force is too great for good results with this method.

Night Balloons.—Hydrogen balloon: Paturels ¾ metre filled to 2 ft. 6 ins. diameter (or 1 metre filled to 3 ft.).

Acetylene balloons: Spencer's 9d. balloons filled to about 16 ins. diameter. Top balloon 20 ft. from Hydrogen balloon and 30 to 35 ft. from bottom one. Brass acetylene burners with quill tube about 12 ins. long inserted in small bore tube mouth of balloon. Suspension by light net, thread replaced by wire at flame. Burners must project *below* balloons.

Theodolite: Micro-wires lit up by reflector from axis lamp or otherwise. Red light best. In No. XXV. above, the acetylene lights were drowned by wire light at Observation No. 15.

Slide-rule (tacheometrical) used for calculations—based on formulæ:

$$H = \frac{206265 \sin a \cos a \times \text{base}}{\text{seconds (micro.-reading)}} \qquad H.D. = \frac{206265 \cos^2 a \times \text{base}}{\text{seconds (micro.-reading)}}$$

where a = altitude, H. = height in feet, H.D. = horizontal distance in feet.

DISCUSSION.

Mr. W. H. Dines said that Capt. Ley's paper was of great interest, and good work had been done in obtaining the observations. He was particularly interested in the method of using acetylene. The results regarding the registering balloons seemed rather disappointing, as only two out of seven had been recovered. Probably the station was too near the coast, and most of the balloons were lost in the Irish Sea. The probability of a balloon crossing the sea to England was remote, and made it hardly worth while to send one up from a station near the sea. One other point he would refer to, was that the formula given for the diameter of a balloon at the bursting point, though it might do very well for the pilot balloons, did not hold generally good. The diameter given would be in excess of that at which the registering balloons burst.

Mr. C. J. P. Cave regretted that Capt. Ley was not present to take part in

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the discussion. He thought that the suction effect of the river Shannon was the effect of cold air flowing down a valley in the evening. He had found that with *ballons-sonde* the descent was quicker than the ascent, but his own burst pilot balloons came down at the same rate as they went up. He wished to congratulate Capt. Ley on his observations, and especially on the use of acetylene lights.

The Hon. C. S. Rolls said that with reference to the last speaker's remarks concerning the suctional effect of rivers, the general impression among aeronauts was that such a drawing effect existed, and was exerted lengthwise. He had often known aeronauts make a landing when crossing a river near its mouth for fear of being carried out to sea by this current. He had, however, carefully observed this, and had only been able to notice it when the river was at the bottom of a deep valley, otherwise the only and invariable effect of nearing water of any kind was to give the balloon a downward drop, owing to the fall of temperature. The author had alluded to his sounding balloons bursting when coming in contact with a cloud; he, Mr. Rolls, did not understand this. The balloon would contract when it came in contact with a cloud and so relieve the tension, but would probably only burst after arriving at the top of the cloud when it came under the direct influence of the sun's rays.

It had often been noticed that the wind followed the contour of the earth, and up to a considerably greater height than Capt. Ley noticed. It was also true that on arriving at the other side of a hill, one got a corresponding collapse in the velocity of the wind, and even a complete change in direction; that is to say, you could drop down on the other side, and travel for a short time in an entirely opposite direction. This, however, was only when quite close to the surface. Higher up, one merely got a gradual rise and fall in the current and no apparent alteration in velocity.

Capt. D. Wilson-Barker said that vertical suction, and not horizontal, over a river was meant. The wind was generally drawn down or up a river, following its course. The wind hardly ever blew straight across a river, but almost always up or down it, and sometimes it followed the actual trend of the river. He should imagine that no effect would be felt as regards the horizontal suction. It was well known that the Thames was warmer in winter and cooler in summer than the surrounding land.

Mr. W. Marriott said that Capt. Ley had been called away rather hurriedly, to take up an appointment in Fiji, and therefore had no time to prepare a discussion on the results obtained from his observations. He promised, however, to write some introductory notes on the observations, and these formed the paper which had been read. The tables of observations were given at the end of the paper, and it was open for any Fellow to discuss these in detail. Capt. Ley, at the request of the Kite Committee, had gone to Ireland with one or two companions to undertake the observations, and Capt. Twiss of Birdhill had rendered him every assistance possible. Capt. Ley had, however, camped out, as he wished to be free to make observations at any time during the night and day. The use of acetylene lights had enabled him to carry out the observations at night.

Mr. W. W. Bryant said that the use of acetylene lights was extremely interesting. The observations obtained by these would be better and less liable to variation than those made by the tangent method described in Capt. Ley's previous communication, and the applicability at night was also a great advance.

The President said they were extremely obliged to Capt. Ley for his kindness in undertaking the work, and must congratulate him on his success in overcoming the difficulties of observation, and for putting the paper together in the hurry of his sudden departure. He, the President, would ask Mr. B. Ley, who was present, to convey to his brother the warmest thanks of the Society.

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The Samoa Observatory.

The Royal Society of Sciences of Göttingen has just published an extensive history and description of the geo-physical observatory that it has maintained at Apia, Samoa, since the summer of 1902. Several charts and photographs accompany this publication. Originally established for a period of only fifteen months, chiefly with a view to obtaining seismological and magnetic observations synchronous with the observations of the German South Polar Expedition, the observatory soon proved to be so valuable that means were found to prolong its life for a further period of five years, and it now seems likely to be made a permanent institution. From the beginning the necessary funds have been provided, half by the German Imperial Government and half by the Prussian Ministry of Education.

The work of the institution is described under four heads: Terrestrial Magnetism, Seismology, Atmospheric Electricity, and Meteorology. The meteorological equipment includes, besides all the ordinary self-recording instruments, a complete outfit for kite-flying, and many successful kite-flights have been carried out.

The observatory is the headquarters of a network of thirty climatological stations in Samoa; and if the plans of its former director, Dr. Linke, are carried out, it will ultimately become the centre of a system of stations extending over all the South Sea Islands from the equator to latitude 35° south.—*U.S. Monthly Weather Review*, Sept. 1908.

Earthquake Weather.

In an article in *Nature*, January 28, on the "Recent Earthquakes," R. D. O. [Mr. R. D. Oldham, the well-known authority on Indian earthquakes] makes the following remarks on earthquake weather:—

"A point which has attracted notice, and is worthy of attention, is the peculiar weather which accompanied and followed the earthquake. We need not consider the fact that it coincided with the sudden break up of an equally sudden and severe frost over Northern Europe, nor the unusual cold and snowstorms which have followed it in Southern Italy. These were due to meteorological conditions of great extent, in all probability unconnected with and independent of the earthquake; but the sudden fog which, according to all accounts, settled on the Straits of Messina stands in a different case. The earthquake in Mexico of January 24, 1898, was similarly followed by a heavy mist, at a time of year when mists are usually unknown; and rainfall is so frequently reported as the immediate successor of an earthquake that we can no longer reject the hypothesis of a real connection between the two. Earthquake weather is a common expression in earthquake countries, but is usually applied to a heavy and oppressive feeling in the air which is supposed to precede an earthquake. Mr. Maxwell Hall has attempted to find an explanation in alterations of the barometric gradient by rapid upheaval of the ground, and has shown that uplifts, which are within the range of possibility, would produce the required effects; but whether there is, or is not, an earthquake weather, in the ordinary sense of the words, there seems reason for believing that in another sense they represent a reality, and that, as has been suggested by Prof. Milne, the disturbance of the ground, when transmitted to the overlying air, may determine precipitation, and explain the apparent association of severe earthquakes with mist and rain. What may be the nature of the influence we know not, but if mechanical, it must be either the result of the vibratory motion of the ground, or else of permanent changes of level, accompanied by the sudden upheaval or depression of the overlying column of air, and of this permanent change of level we are still without any satisfactory evidence."

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SOME FORMS OF SCIENTIFIC KITES.

By ERIC STUART BRUCE, M.A., F.R.Met.Soc.

[Read December 16, 1908.]

The value of the kite for obtaining meteorological observations at altitudes where there is freedom from terrestrial influences, is well emphasised in Mr. E. Gold's recent report, "On the Variation of Meteorological Elements with Altitude." Another recent demonstration of the usefulness of the kite in research is the observations in atmospherical electricity made by its means at the Manchester University's meteorological observatory at Glossop in July and August last. It is no exaggeration to say that kite observations in the free and open air, coupled with those other observations gained by the use of *ballons-sonde* at still greater heights, are laying the foundation of what may be aptly called "The New Meteorology."

The object of this paper is to bring before the notice of this Society some forms of scientific kites other than the now well-known box-kite invented by Mr. Hargrave. This is heavier and more breakable than many other forms of kites, but it possesses the indisputable advantages of stability, ascending steeply and exerting great force. When there is wind enough to fly it, it would appear unsurpassed.

It is, however, advisable that meteorological kite-ascents should be carried out as continuously as is possible, and that as many as possible of those days when the heavier box-kite will not rise, should be utilised for obtaining information.

On this account, those lighter forms of kites, which are specially adapted for use in very light winds, may be of intense service. One, at least, has been successfully pressed into the service of upper-air investigation on days when the box-kite failed to be of any use. It seems not unreasonable to suggest that each meteorological kite-station should possess every resource obtainable to secure continuity of records, and that as well as possessing box-kites, should be supplied with a supplementary equipment of lighter kites to take their place on days of low wind-force. Some of these lighter forms of kites were brought from obscurity into the light of day by two events, with whose organisation I have been closely associated: viz. (1) The International Kite Competition, which took place under the auspices of the Aeronautical Society of Great Britain in 1903; and (2) The Kite Display undertaken by the same Society in 1907.

An example of a kite that can be successfully used in light winds is the Brogden Six-Winged Bird-Kite (Fig. 1). This kite attained the highest records both as regards the mean of the Theodolite observations for altitude (1534 feet), and the actual greatest height observed for the kites (1816 feet), in the kite competition of 1903. On this occasion no kite attained the height required (highest point above 3000 feet); but the Brogden kite showed its capacity for high flights on the occasion of the kite display in 1907, for on that occasion it was estimated that it rose fully to the height of 3000 ft., 3800 ft. of wire being out. The angle of

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the kite was fairly constant at 56° to 60° from the horizontal. I am indebted to Mr. Brogden for the following details as to the construction of this kite.

The area of the kite is 110 sq. ft. The height is 17 ft. and the width 18 ft. 8 ins. The wings are so constructed that they give at their after edge, and the dihedral angle of the kite remains unchanged, as also the position of the kite in the air. The flying wire is attached low on the bridle, bringing the kite well facing the wind. The wings then assume the form of a bird's wing, being not planes but curves from back to front. The backbone is neither straight nor an even curve. The front or head end curves upwards, while the after part curves very slightly downwards. The head or lead, which is the triangular part in front of the front pair of wings, has therefore a slightly upward turn. This prevents the kite from dipping, but is not sufficient to cause much drift. The air forced under the lead spreads and fills the curves of the wings, gliding off from the back edge of these, and so tending to force the kite forward.



FIG. 1.—Brogden's Six-Winged Bird-Kite.

An important feature of the construction is the bamboo struts which cross the kite above the backbone and preserve the dihedral angle of the kite.

Another very promising specimen of a kite suitable for light winds is Mr. S. Salmon's Eighteen-Winged Kite, which he made specially for the kite display of 1907. This has nine wings at each side of the backbone, which is 18 ft. high. The wings have a span of 10 ft. from tip to tip. The effective area of the kite is estimated to be 40 sq. ft. The weight is 8 lbs. (Figs. 2 and 3).

Mr. Salmon claims that this type of kite is excellent for light winds, and very easy to manipulate. He states that a kite of this type has often enabled him to raise a meteorograph 1600 ft. when a box-kite would not leave the ground.

These claims certainly appeared to be borne out by the admirable performance of this kite at the kite display at Sunningdale. The panoramic photograph of this display taken when some of the eleven kites shown were at a considerable altitude, show the Brogden and Salmon kites in the air. The objects are necessarily very faint on account of the extreme heights of the kites.

Mr. Salmon has experimented with a large variety of kites of his own construction as well as those of others. At the kite competition in 1903 a very good flight was made with his Multiple-Celled Rhomboidal Kite. This is worthy of further comparative tests.

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A novel form of kite is the Barclay Honeycombed Kite. This was originally copied from a French pattern described by M. J. Lecornu. The particular virtue of this kite appears to be its property of ascending very perpendicularly. Mr. Salmon, who has experimented with this form of kite, states that the string of such a kite can make an angle of almost 80° with the ground.

On the occasion of the kite competition in 1903 it was anticipated that the Cody Bat-Winged Box-Kite would easily attain the highest position. But the comparative tests on that occasion only gave it the

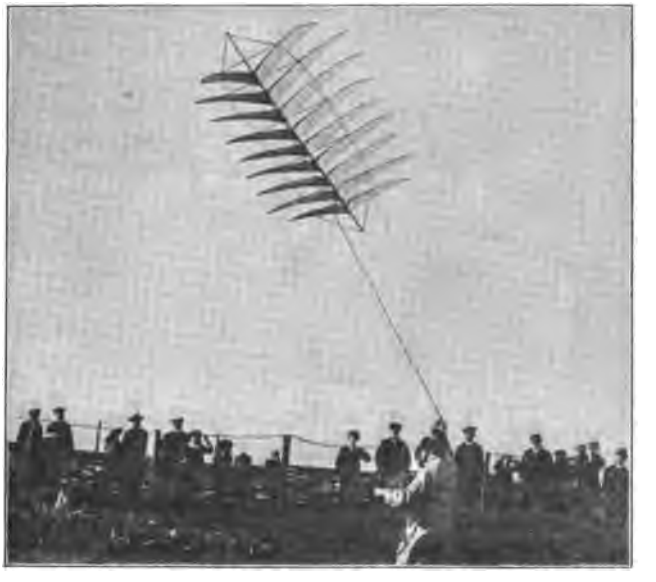


FIG. 2.—Salmon's Eighteen-Winged Kite.

second place, it being beaten by the Brogden bird-kite described above. Probably the very light wind prevailing on that occasion was responsible for the unexpected results. Recent experiments with this form of kite at Aldershot in connection with the military balloon department have proved not only its flying qualities, but its man-lifting qualities. Its services have been rightly absorbed by the British Government. Had they not been so absorbed a series of comparative tests with this form of kite and the ordinary box-kite would not have been without interest.

While speaking of recent developments in kites suitable for light winds, mention should be made of Mr. Balston's pretty Butterfly kites, which he has specially devised for use in light winds (Fig. 4). Mr. Balston claims that this kite is quite stable. The lateral stability is obtained by setting the wings at a slight dihedral angle. The balance is maintained longitudinally by placing the after-plane, *i.e.* the hind-wing, at an angle to the front ones, so that the front planes always lie at a greater angle to the wind than the back ones. Consequently, before the front planes get into a position to dive, the after-planes have been lifted off the wind

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and their weight is employed in bringing the kite back to its normal balance.

An undoubtedly interesting kite is the aluminium kite of Mr. Alan Burgoyne (photographs shown). The sides of the three boxes are made of eight rods 6 ft. long and $\frac{1}{4}$ in. thick. The wing-supports consist of one $\frac{5}{8}$-in. rod 12 ft. 3 in. in length passing right across the kite, and

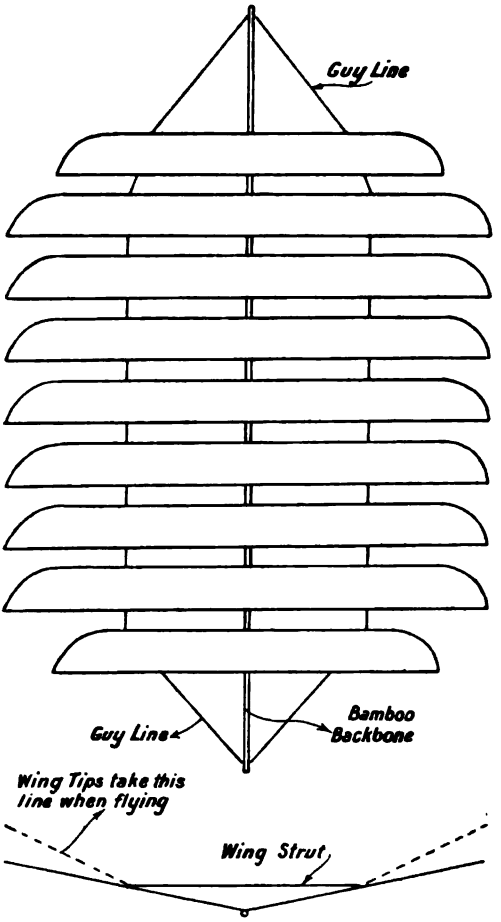


FIG. 3.—Outline Sketch. (Scale, $\frac{1}{4}$ inch = 1 foot.)

secured by lashings to each box in turn. The tube fore and aft is also of $\frac{5}{8}$-in. rod, and is wired with strain eye-attachments to all eight box-rods. In fact, the strain is distributed evenly from the tips of the wing-rod to the tips of the fore-end after-rod, making a tightly braced quadrilateral.

Two 3-feet tubes are used as vertical supports, and at the bottoms of these were placed two small wheels, so that the transport of the kite, when set up, is greatly facilitated.

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The extreme breadth from tips of wings is 12 ft. 8 in.; the extreme length, 10 ft. 9 in. The weight is 12¾ lbs.

The highest flight obtained with this kite was between 10,000 and 12,000 ft.

Further experiments with this kite would be of interest, though it is questionable whether the use of aluminium would be an advantage in kite construction considering its extreme brittleness.

The work that has already been done with scientific kites in this country by Mr. W. H. Dines, Mr. Charles Cave, Mr. Salmon, and others



FIG. 4.—Balston's Butterfly Kite.

would seem sufficient to justify the hope that, before very long, a permanent national aerial observatory may be established in this country, where will be gathered together every useful form of kite, and, in fact, every contrivance that is fittest to further the investigations of the upper air. It may be said that the establishment of such an aerial observatory in this country will be beset with difficulty. But a difficulty is something to be overcome. Looked at in this light, it is the incentive to work. Its presence is the guarantee that our object is worthy of the exercise of our will and the expenditure of our energies.

The establishment of a well-equipped national aerial observatory is an object that will justify individual and corporate effort: First, for the sake of the knowledge which will therefrom be revealed; second, for the sake of the far-reaching practical results that knowledge will confer on mankind.

Winds encountered from Seychelles to Aldabra.

It may be said, generally speaking, that south of the equator a North-west monsoon is prevalent when the sun has south declination, and a South-east monsoon when its declination is north. Thus in our monsoon region in the Southern Indian Ocean we have two seasons' winds of variable duration. In no case does one monsoon terminate abruptly and the other commence forthwith; but there is a period of change, known as the breaking up of the monsoon. When our monsoon is about to cease, the season wind varies in direction and force, and is occasionally replaced by calm. The evidence of disturbance is indicated by the overcasting of the sky and a hazy horizon both at sunrise and

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sunset. By watching the upper clouds carefully, we may be able to estimate the direction of the succeeding monsoon. The North-west monsoon in our region blows from December to April, and the South-east monsoon from May to October, sometimes till November. Properly speaking, November is a month of light variable breeze and calm. I noticed a great difference between the North-west monsoon last year and this year. Last year I left Mahé for Aldabra just at the break of the North-west monsoon (December 7, 1906), and only reached Aldabra on January 2, 1907. The weather was generally unsettled and dull, with light air at intervals and calm, the sky being frequently cloudy at sunset. I was becalmed for a month and a half in the vicinity of Astove, Cosmoledo, and Aldabra Islands, drifting with the currents all the time until I was out of the calm region, when I got a light breeze variable from South-west to North-west, freshening a little in the morning and calming down in the afternoon. I estimate this calm belt to be between lat. 8° to 11° S., and long. 45° to 48° E.; outside of that I always had a little breeze. Finally I reached Seychelles on March 5, 1907.

This year there has been no breaking up of the monsoon. The wind shifted all of a sudden from South-east to West and North-west during a cyclone which visited these islands early in November. Since then the wind has been very regular and steady during the whole period of the North-west monsoon, and has enabled me to make four voyages from Seychelles to Aldabra Island, whilst last year I was three months out to make one voyage. During January, February, and March I have experienced very strong breezes, frequently increasing in force at full and change of moon, with heavy rain. During the whole period of the North-west monsoon we have a fine and moderate sea, whilst during the South-east monsoon it is something fearful. The South-east trade blows here more persistently than at Seychelles nearly all the year round. We can rely upon the steady trade wind for eight or nine months in the year.

The breaking up of the South-east trade this year has been something similar to that of the North-west monsoon. I left Mahé for the Aldabra groups on April 21, 1908, just at the breaking up of the South-east trade. I carried light North-easterly winds from Mahé to Providence Island. At about 2 P.M. on the 26th, being in sight of St. Pierre Island, I noticed a great change in the weather, the sky clouding over suddenly with very low clouds moving rapidly from the South-east, sea rising, and the barometer very high, 30·08 ins., all indicating a heavy blow from South-east. I decided to anchor at St. Pierre Island for shelter during the night; brought to, and anchored at 6 P.M. At 7 o'clock the ship dragged her anchor, and I could not fetch the island again, so had to continue my course to Astove Island. During the night I experienced a heavy gale from the South-south-east, with tremendous high waves from the south-east; the ship laboured a great deal, rolling and pitching heavily in the trough of the sea, and at 10 P.M. my main-topmast was carried away. Bore away to bring the wind and sea two points abaft the beam to steady the vessel a little. At daylight on the 27th the gale was increasing in force, and the sea very dangerous. Bore away again under topsail and a reefed mainsail, and ran with the wind and sea on the port quarter, ship making 10 knots. Sighted Astove at 4.30 P.M., sea getting more dangerous and heavier. As I was closing on the land I estimated these waves to be about 25 or 30 feet high. At 5.30 my foregaff and fore-topmast were carried away. Impossible to board the island, the surf being too heavy at the anchorage, and had to bear away for Assomption and Aldabra, where I could get my topmast and riggings repaired. I am of opinion that a slow steamer, as the *Longwood*, etc., would have surely sustained some serious damage or foundered in such a sea.—Capt. R. PARCOU, Victoria, Seychelles, *June* 1908.

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THE REGISTERING BALLOON ASCENTS IN THE BRITISH ISLES, JULY 27–AUGUST 1, 1908. *Preliminary Account.*

By C. J. P. CAVE, F.R.Met.Soc.

[Read December 16, 1908.]

As in 1907 the International Commission for Scientific Aeronautics arranged for an extended series of ascents of kites and balloons during the last days of July in the present year. It will be some time before the full results of the ascents are published, but it is desirable that a preliminary account of the result of the balloon ascents made in this country should be put on record, as was done by Mr. Dines for the ascents of 1907.

The days on which ascents were made were July 27, 28, 29, 30, 31, and August 1. Twelve balloons were sent up for the Meteorological Office under the direction of Mr. W. H. Dines, F.R.S., six ascents being from Crinan on the west coast of Scotland, and six from Pyrton Hill, Oxfordshire; six were sent up by the Meteorological Department of the Manchester University under the direction of Mr. J. E. Petavel, F.R.S.; six by Capt. C. H. Ley from Birdhill, Co. Limerick, for the Kite Committee; and four by myself from Ditcham Park, Petersfield, Hants. Of those sent up, four from Crinan, five from Manchester, three from Pyrton Hill, and two each from Birdhill and Ditcham have been recovered.

In every case the instruments used were made at Pyrton Hill, and were of the type designed by Mr. Dines and described in *Symons's Meteorological Magazine* for July 1906, and in the *Quarterly Journal of the Royal Meteorological Society* for January 1908. The traces were made on copper electroplated with silver; they are clearer than those made on plain copper, and remain quite readable, even when the plate has been exposed to the weather for a considerable time, or has been acted on by sea water.

With one exception all the balloons were sent up within about an hour of sunset; the ascent from Crinan on July 31 began at 8.10 a.m.

Some of the records show considerable differences of temperature between the up and the down traces, which seems to indicate that fairly rapid fluctuations of temperature may take place in the upper air; but it must be remembered that the balloons drift considerable distances even during the short time occupied by the ascent, so that the ascent and descent take place through air over widely different localities.

The average height reached was 16·4 kilometres (10·2 miles), or more than 4 kilometres (2·5 miles) higher than last year. The greatest height was 23 kilometres (14·3 miles) from Pyrton Hill, and the least was 7 kilometres (4·4 miles) from Glossop Moor—the balloon in this case having burst prematurely. In the case of very high ascents, as has been pointed out by Mr. Dines in his paper on the ascents of last year, the actual height cannot be determined accurately within a kilometre or so. All the balloons except one reached the isothermal layer, and show that the diminution of temperature with height ceases after a certain point, or that there is a rise of temperature; the rise of temperature is sometimes quite marked even in the case of balloons which have attained their highest point after sunset, and cannot therefore be the effect of solar radiation. Balloons sent up in the daytime show a still more marked rise of

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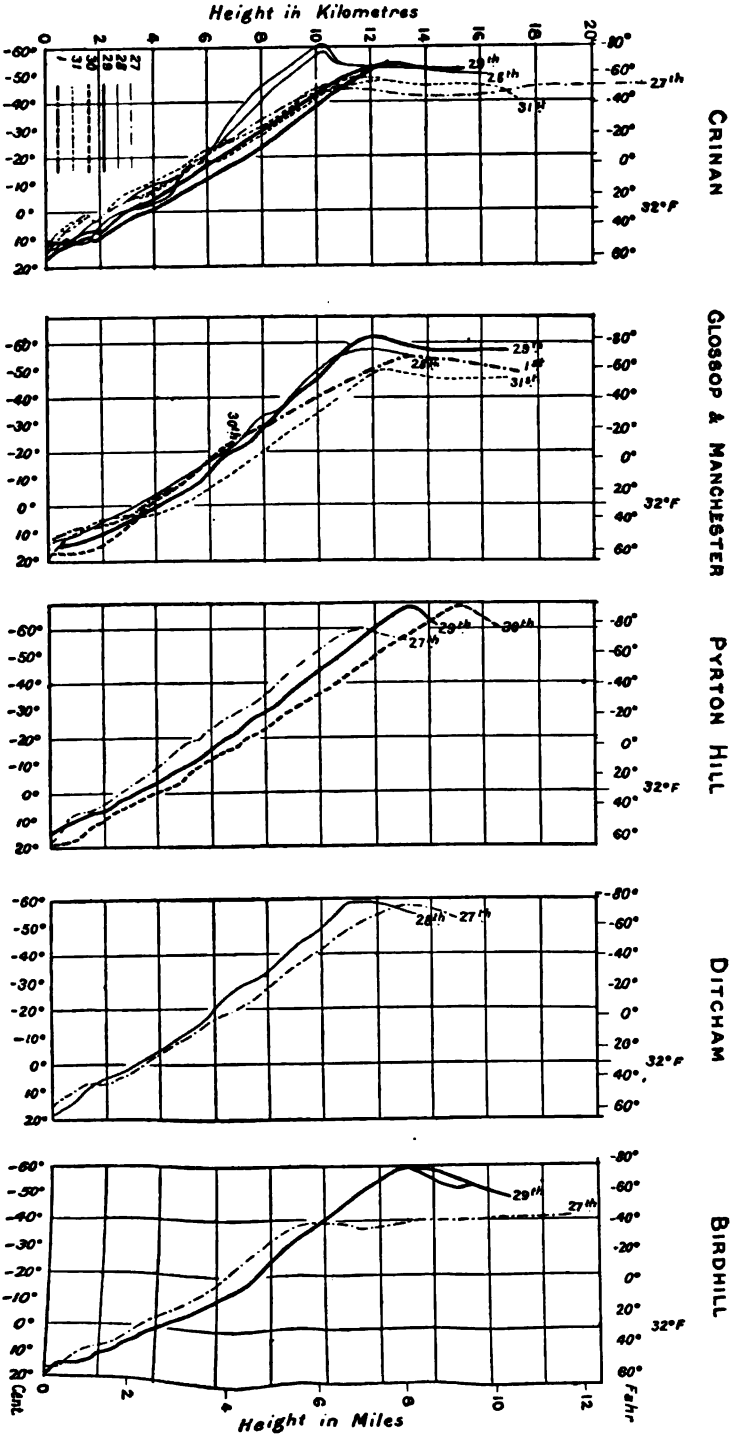


FIG. 1.—Temperature with Height.

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temperature at the highest points, due, no doubt, to the effect of sunshine on the instrument.

TABLE I.—Temperatures at Various Heights.

Heights.	July 27.		July 28.		July 29.		July 30.		July 31.		Aug. 1.	
	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
Ground-Level.												
Crinan	15°	59°	13°	55°	16°	61°	...	...	13°	55°	...	...
Glossop	...	...	12	54	14	57	16	61	18	64	...	...
Pyrton Hill	17	63	...	...	14	57	18	64	...	...	...	...
Ditcham Park	16	61	19	66	...	...	...	...	...	...	...	...
Birdhill	18	64	...	...	19	66	...	...	...	...	...	...
3 Kilometres—1·9 Miles.												
Crinan	− 4	25	1	34	3	37	...	...	− 7	19	...	...
Glossop	...	...	1	34	5	41	6	43	3	37	5	41
Pyrton Hill	− 2	28	...	...	0	32	3	37	...	...	...	...
Ditcham Park	2	36	1	34	...	...	...	...	...	...	...	...
Birdhill	5	41	...	...	6	43	...	...	...	...	...	...
6 Kilometres—3·7 Miles.												
Crinan	− 21	− 6	− 21	− 6	− 12	10	...	...	− 23	− 9	...	...
Glossop	...	...	− 16	3	− 14	7	− 16	3	− 7	19	− 16	3
Pyrton Hill	− 24	− 11	...	...	− 17	1	− 14	7	...	...	...	...
Ditcham Park	− 17	1	− 19	− 2	...	...	...	...	...	...	...	...
Birdhill	− 16	3	...	...	− 11	12	...	...	...	...	...	...
9 Kilometres—5·6 Miles.												
Crinan	− 39	− 38	− 50	− 58	− 31	− 24	...	...	− 39	− 38	...	...
Glossop	...	...	− 40	− 40	− 40	− 40	...	...	− 27	− 17	− 35	− 31
Pyrton Hill	− 46	− 51	...	...	− 39	− 38	− 32	− 26	...	...	...	...
Ditcham Park	− 36	− 33	− 43	− 45	...	...	...	...	...	...	...	...
Birdhill	− 38	− 36	...	...	− 34	− 29	...	...	...	...	...	...
12 Kilometres—7·5 Miles.												
Crinan	− 45	− 49	− 54	− 65	− 53	− 63	...	...	− 50	− 58	...	...
Glossop	...	...	− 58	− 72	− 63	− 81	...	...	− 49	− 56	− 50	− 58
Pyrton Hill	− 58	− 72	...	...	− 61	− 78	− 51	− 60	...	...	...	...
Ditcham Park	− 55	− 67	− 58	− 72	...	...	...	...	...	...	...	...
Birdhill	− 38	− 36	...	...	− 56	− 69	...	...	...	...	...	...
15 Kilometres—9·3 Miles.												
Crinan	− 43	− 45	− 52	− 62	− 52	− 62	...	...	− 47	− 53	...	...
Glossop	...	...	...	...	− 57	− 71	...	...	− 47	− 53	− 54	− 65
Pyrton Hill	...	...	...	...	− 60	− 76	− 69	− 92	...	...	...	...
Ditcham Park	− 54	− 65	− 55	− 67	...	...	...	...	...	...	...	...
Birdhill	− 40	− 40	...	...	− 53	− 63	...	...	...	...	...	...
18 Kilometres—11·2 Miles.												
Crinan	− 46	− 51	...	...	...	...	...	...	...	...	...	...
Glossop	...	...	...	...	...	...	...	...	...	...	− 48	− 54
Pyrton Hill	...	...	...	...	− 58	− 72	...	...	...	...	...	...
Ditcham Park	...	...	...	...	...	...	...	...	...	...	...	...
Birdhill	− 41	− 42	...	...	...	...	...	...	...	...	...	...

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The balloons from Ditcham were all sent up about an hour before sunset, in order that theodolite observations might be made as long as possible. It is probable that at such a late hour no effect would be produced on the instruments by the sun's rays. The balloon on July 27 shows considerably higher temperatures than that sent up an hour later from Pryton Hill, but this particular balloon did not get into direct sunlight till 29 minutes after the start, when it was probably about 7 kilometres (4·4 miles) high, whereas the differences of temperature between Ditcham and Pyrton Hill are shown to occur at much lower levels; moreover, there is no sign on the trace of any sudden increase in temperature at about the height named.

The relation between height and temperature for the ascents at each of the five stations is shown in Fig. 1 (p. 38).

The results obtained are summarised in Table I.

In Table I. the highest values for the temperature are given in those cases in which the trace is duplicated, except in the case of the day ascent at Crinan on July 31, where the lowest of the two sets of temperature values is given.

Table II. gives the temperature gradient for each ascent from the ground-level to 5 kilometres (3·1 miles), from 5 to 10 kilometres (3·1 to 6·2 miles), and from the ground-level to the commencement of the isothermal layer. The gradient is given in degrees Centigrade per 100 metres (330 ft.).

TABLE II.—Temperature Gradients. Centigrade.

Stations.	July 27.	July 28.	July 29.	July 30.	July 31.	Aug. 1.
Crinan.						
0 to 5 km. (0 to 3·1 miles)	·56°	·52°	·45°	...	·56°	...
5 to 10 km. (3·1 to 6·2 miles)	·60	·90	·64	...	·57	...
0 to Isothermal	·58	·71	·58	...	·54	...
Glossop.						
0 to 5 km. (0 to 3·1 miles)	...	·44	·40	·48	·38	·36
5 to 10 km. (3·1 to 6·2 miles)	...	·78	·84	...	·66	·62
0 to Isothermal	...	·61	·64	...	·54	·49
Pyrton Hill.						
0 to 5 km. (0 to 3·1 miles)	·70	...	·44	·48	...	...
5 to 10 km. (3·1 to 6·2 miles)	·70	...	·72	·62	...	...
0 to Isothermal	·67	...	·61	·56	...	...
Ditcham Park.						
0 to 5 km. (0 to 3·1 miles)	·61	·60	...	...	...	...
5 to 10 km. (3·1 to 6·2 miles)	·64	·78	...	...	...	...
0 to Isothermal	·57	·72	...	...	...	...
Birdhill.						
0 to 5 km. (0 to 3·1 miles)	·56	...	·48	...	...	...
5 to 10 km. (3·1 to 6·2 miles)	·60	...	·72	...	...	...
0 to Isothermal	·61	...	·61	...	...	...

In the above table the mean values are taken in the cases where the traces are duplicated. It will be noticed that the gradients vary considerably, but in every case save one the value is lower from 0 to 5 km.

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(3·1 miles) than it is from 5 to 10 km. (3·1 to 6·2 miles). Above the lower limit of the isothermal layer the gradients are in most cases reversed, and in several cases a very sharp rise of temperature takes place at the beginning followed by a slow increase above. Near the ground-level there are, as usual, numerous irregularities in the gradient and several small inversions.

Table III. shows the height at which the isothermal layer was entered in the different ascents.

TABLE III.—Height of Lower Limit of Isothermal Layer.

Station.	July 27.		July 28.		July 29.		July 30.		July 31.		Aug. 1.	
	Km.	Miles.	Km.	Miles.	Km.	Miles.	Km.	Miles.	Km.	Miles.	Km.	Miles.
Crinan . .	10·5	6·5	10·5	6·5	12·5	7·8	...	...	11·5	7·2	...	...
Glossop . .	...	...	11·5	7·2	12	7·5	...	...	12·5	7·8	13	8·1
Pyrton Hill .	11·5	7·2	...	...	13·5	8·4	15·3	9·5	...	...	...	...
Ditcham Park .	13	8·1	11	6·8	...	...	...	...	...	...	...	...
Limerick . .	9·5	5·9	...	...	13	8·1	...	...	...	...	...	...

It must be remembered that the lower limit of the isothermal layer is not always a very definite point, and the above figures must be taken with this proviso.

It will be noticed from Table I. that the temperatures at different heights change considerably from day to day, and from place to place. Fig. 2 shows graphically the changes that took place at Crinan, Glossop, and Pyrton Hill for the days indicated in the figure, the heavy dotted line showing the lower limit of the isothermal layer.

Crinan, Glossop, Pyrton Hill, and Ditcham are nearly in a line, and Fig. 3 shows graphically the differences of temperature between the

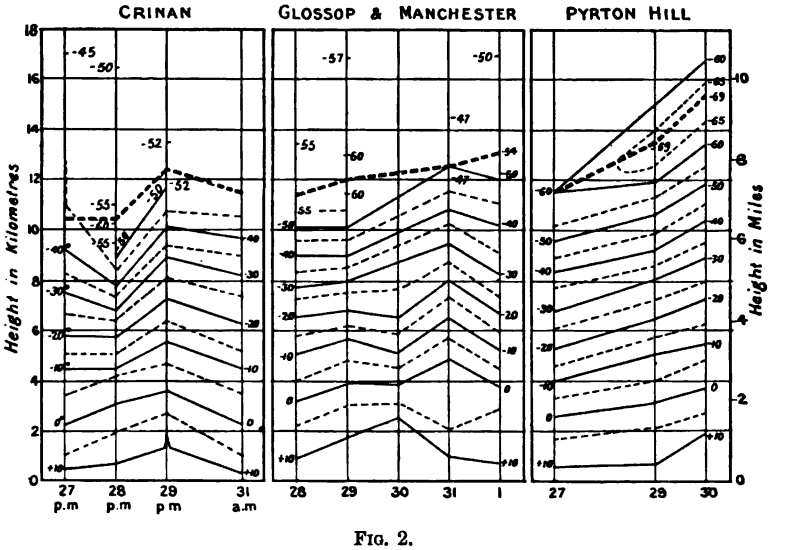


Fig. 2.

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stations indicated for July 27, 28, and 29, the distances between the stations being drawn to scale. The isothermal lines must only be taken to represent the relation of temperature between the stations; it is quite likely that had observations been taken at intermediate stations the lines would lie differently from those shown in the figures. It is unfortunate that on no day were the balloons from all four stations recovered. It must also be remembered that as a balloon drifts to considerable distances during an ascent, the temperatures recorded are not those directly over any one station.

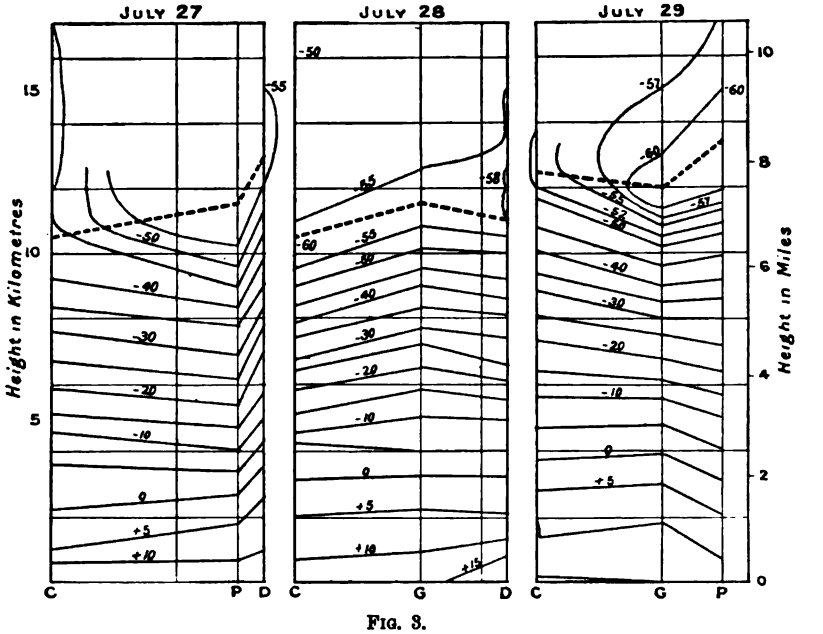


FIG. 3.

The weather during the week was of an anticyclonic type. On the evening of the 27th an area of high pressure lay over this country with its centre off the south-west coasts with barometer readings of 30·2 in. and upwards; by next day the barometer readings had increased to 30·4 in., and the centre of the anticyclone had moved more towards Ireland; changes were slow during the week, and by the evening of August 1 the centre of the high-pressure system lay off the north-west coast of Ireland.

In view of the many ascents that have now been made both in this country, in Europe and America, and over the Atlantic, the existence of the isothermal layer cannot for a moment be doubted. The actual temperatures recorded may in some cases be more or less in error, but the existence of the isothermal layer cannot by any possibility be explained away by appealing to instrumental errors.

The fact that there should be an isothermal layer at the upper limit of the air movements of cyclones and anticyclones is not in itself a difficulty, but it is very difficult to account for the large differences of temperature within the isothermal layer which are found from day to day, and from place to place.

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BALLOON OBSERVATIONS AT DITCHAM PARK, NEAR PETERSFIELD, JULY 27–AUGUST 2, 1908.

By C. J. P. CAVE, F.R.Met.Soc.

[Read December 16, 1908.]

The registering balloons sent up from Ditcham Park during the ascents at the end of July were followed by means of theodolites for the determination of wind velocities at different heights. The theodolites used were of the pattern specially designed by M. de Quervain for balloon observations. A base line of 8800 ft. was used, the two ends being designated A and L. The method of starting the balloons was as follows:—When the observer at L had set up his theodolite he hoisted a flag; the balloon was then brought out at A ready for the start; one minute before the start a flag was hoisted at A, and was dropped ten seconds before the balloon was liberated; at the moment of the start the observer at L started a stop-watch, and observations were made of the altitude and bearing of the balloon at each station at every minute as long as the balloons remained visible. The balloons were started about an hour before sunset, and the evenings being clear it was found that they could be followed to very great distances. The base line was too short for the more distant parts of the course to be plotted from the two sets of observations; the course was plotted trigonometrically as far as practicable, after which the observations from one station were taken, and the height of the balloon was obtained on the assumption that the rate of ascent remained uniform. Theoretical considerations and the results of more recent ascents show that the rate of ascent is not uniform, but that it increases for a considerable time with increasing height.

In cases where the balloon carries a meteorograph and is seen to burst, a fair approximation may, I think, be obtained by taking the rate of ascent from the two sets of observations till the balloon gets too far away, and subsequently assuming a uniform acceleration whose value is chosen to fit in with the bursting height given by the meteorograph. In the present case this method cannot be applied, as the balloons that were seen to burst were not recovered. The rate of ascent does not always increase with height; a small leak, for instance, may cause it to remain uniform or even to decrease. I have observed a small pilot balloon, whose positions were very favourable with regard to the base line, and whose rate of ascent was uniform up to 28,000 ft. In dealing with the present ascents a uniform rate of ascent is assumed where the two-theodolite method is not applicable.

The balloons used were Paturel's 1·75 metre (5·7 ft.) balloons, and were given a free lift of 0·8 kg. (1·8 lbs.) when they were about 1·2 metres in diameter (3·9 ft.); they were uncoloured; trailing below the instruments was a smaller balloon, which was given a very small lift, and served as a check to the descent of the instrument and as a guide to its being found. It was owing to the small balloon that the instrument of July 28 was recovered. The white balloons were very clearly visible in the sunlight against the blue sky.

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Fig. 1. shows the trajectories of the balloons sent up on July 28, 29, 30, and 31; the coast-line has been inserted, and it will be seen that all four balloons went over the sea. The balloon of July 28 was not seen to burst; it was recovered on August 1, 18 miles east of Cape Barfleur, off the French coast. The balloon of July 29 was seen to burst, and was seen falling for six minutes, but was not recovered. That of July 30 was lost sight of before it burst; for the last twelve minutes of the observations the sun was not shining on it, and the dark balloon

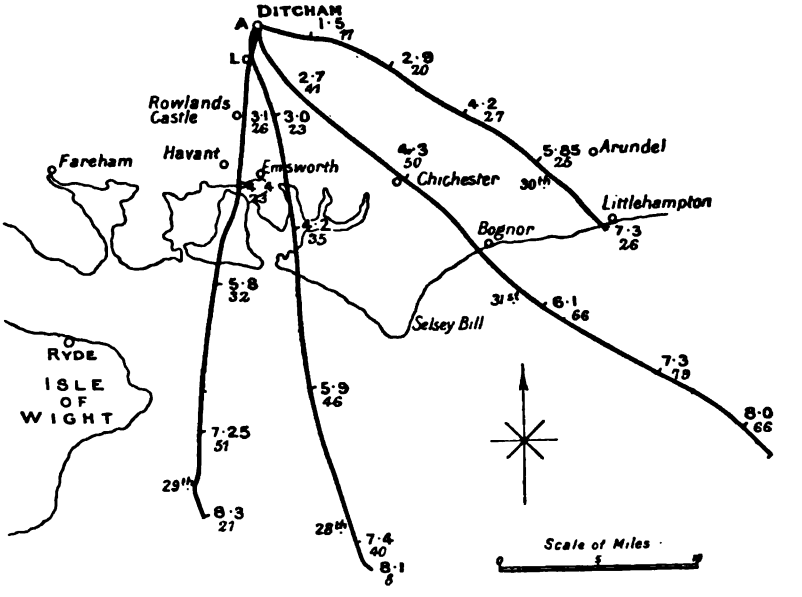


Fig. 1.—Trajectories of the Balloons. The upper figures indicate the approximate height in miles; and the lower figures, the Wind Velocities in miles per hour.

alone remained visible. The balloon of July 31 was a similar balloon to those used on the previous days, but it carried no instrument, and no small balloon was attached; it was seen to burst at a distance of about 33 miles, and was watched as it fell for one minute.

The wind velocities deduced from the observations are shown in Fig. 2, the curves having been smoothed. On July 28 the wind was very light near the ground, but increased to 50 miles per hour at 8 km. (5 miles), and remained fairly constant from 8 to 11·5 km. (5 to 7·2 miles), when a maximum of 55 miles per hour was reached; then there was a rapid drop to 8 miles per hour at 13 km. (8·1 miles); above 8 km. (5 miles) the wind backed at first slowly, but at 12·5 km. (7·8 miles) it backed quickly to North-west at the highest point observed. The meteorograph showed that the isothermal layer was reached at about 11 km. (6·8 miles), corresponding nearly to the point of maximum wind velocity. The features of July 28 were nearly repeated on the 29th; the velocity increased rather more slowly at first, but a maximum of about 55 miles per hour was reached at 11·5 km. (7·2 miles); the

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decrease above was slower, but was quite as marked; there was also a backing of the wind at 12·5 km. (7·8 miles); the Pyrton Hill balloon went into the isothermal layer at 13·5 km. (8·4 miles); the Glossop balloon, at 12 km. (7·45 miles). On July 30 the wind velocities were much lower; after several fluctuations a maximum of 35 miles per hour was reached at 10·5 km. (6·5 miles), followed by a moderate decrease; this balloon was probably not seen to go into the isothermal layer, which was reached at 15·3 km. (9·5 miles) at Pyrton Hill on this day.

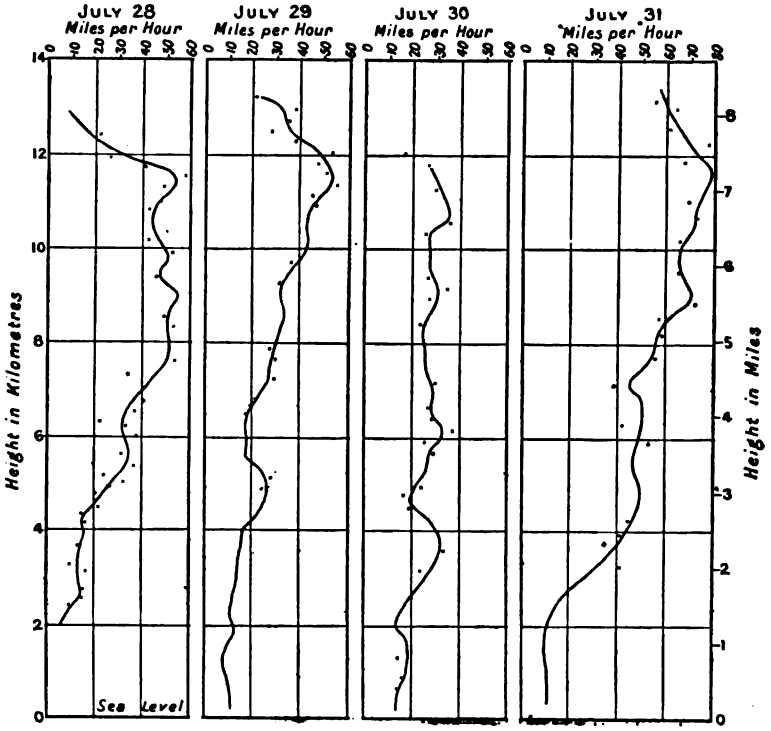


Fig. 2.—Wind Velocities in miles per hour.

On July 31 the velocity increased from 10 miles per hour to 50 miles per hour at 5 km. (3·1 miles); after several fluctuations a maximum of 80 miles per hour was reached at 11·5 km. (7·2 miles); above this there is a marked though not rapid diminution of wind velocity, which was about 55 miles per hour at 13·5 km. (8·4 miles). The Manchester balloon for this day entered the isothermal layer at 12·5 km. (7·8 miles).

For the reasons stated above, too much reliance must not be placed on the absolute values of heights and wind velocities in the higher parts of the ascents; but it is fairly certain that the balloons of July 28, 29, and 31 were observed until after they had entered the isothermal layer, and in each case there was a well-marked diminution of wind velocity at about the height one would expect to find its lower limit.

Besides the four balloons mentioned above, observations were made on the registering balloon of July 27 to a height of about 8·5 km. (5·3

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Wind Velocities in Miles per Hour and Wind Directions.

Date.	Time.	Height. Ground-Level.	Km. 0·5 / Mls. 0·3	1·0 / 0·6	1·5 / 0·9	2·0 / 1·2	3·0 / 1·9	4·0 / 2·5	5·0 / 3·1
July 27	7.19 p.m.	9. W 10° S	9. W 40° N	3. S 30° W	2. S 30° W	16. S 20° W	14. S 40° W	17. S 35° W	27. S 25° W
,, 28*	7 p.m.	...	...	...	...	5. N 30 W	13. N 25 W	15. N 25 W	27. N 10 W
,, 29	9.27 a.m.	12. N 30 E	18. N 15 E	15. N 30 W	12. N 20 E	13. N 15 E	18. N 25 E	13. N 15 E	...
,, 29	5.3 p.m.	7. N 10 W	8. N 5 E	8. N 30 E	7. N 5 W	15. N 5 E	14. N 20 E	16. N	19. N 5 E
,, 29*	7 p.m.	11. N	11. N	10. N 10 E	9. N 10 E	12. N 25 E	14. N 10 E	16. N 5 E	26. N 5 E
,, 30	8.6 a.m.	5. W	9. W 5 N	3. W 5 N	11. N 25 W	12. N 5 W	20. N	17. N 15 W	17. N 10 W
,, 30	12.36 p.m.	6. N 60 W	6. N 75 W	6. N 75 W	7. N 35 W	9. N 35 W	16. N 40 W	11. N 45 W	...
,, 30*	7 p.m.	14. W 5 S	14. W 20 N	18. W 15 N	19. W 15 N	13. W 15 N	25. W 5 N	30. W 30 N	23. W 35 N
,, 31*	7 p.m.	11. N 5 W	11. N 5 W	10. N	9. N	11. N 20 W	25. N 30 W	44. N 40 W	48. N 50 W
Aug. 1	8.10 a.m.	11. N 5 W	15. N 10 E	18. N	27. N 20 W	24. N 15 W	32. N 10 W	...	...
,, 1	5.53 p.m.	9. N 10 W	12. N 10 W	10. N 15 W	25. N 5 E	29. N 5 W	31. N 5 W	42. N	...
,, 1	7.5 p.m.	15. N 15 W	19. N 10 W	10. N 10 E	20. N 5 E	27. N 5 W	32. N 10 W	42. N	...
,, 2	5.34 p.m.	8. S 5 E	6. N 5 W	16. N 15 E	24. N 20 E	30. N 30 E	29. N 25 E	37. N 10 E	...
,, 2	7.30 p.m.	3. W 25 S	7. N 45 E	15. N 25 E	19. N 30 E	29. N 40 E	28. N 25 E	28. N 15 E	...

Date.	Time.	Height. Km. 6·0 / Mls. 3·7	7·0 / 4·4	8·0 / 5·0	9·0 / 5·6	10·0 / 6·2	11·0 / 6·8	12·0 / 7·5	13·0 / 8·1
July 27	7.19 p.m.	40. S 40° W	48. S 30° W	58. S 35° W	...	...	...	...	...
,, 28*	7 p.m.	32. N 5 W	40. N 10 W	51. N	54. N 5 W	50. N 10 W	48. N 20 W	32. N 25 W	7. N 50 W
,, 29	9.27 a.m.	...	...	...	...	...	...	...	...
,, 29	5.3 p.m.	...	...	...	...	...	...	...	...
,, 29*	7 p.m.	18. N 5 E	24. N 5 E	30. N 25 E	31. N 15 E	43. N 10 E	46. N 5 E	50. N	30. N 10 W
,, 30	8.6 a.m.	...	...	...	...	...	...	...	...
,, 30	12.36 p.m.	...	...	...	...	...	...	...	...
,, 30*	7 p.m.	32. W 40 N	28. W 25 N	24. W 30 N	30. W 40 N	26. W 35 N	33. W 45 N	...	...
,, 31*	7 p.m.	49. N 50 W	45. N 55 W	55. N 40 W	70. N 45 W	66. N 50 W	74. N 55 W	72. N 55 W	60. N 45 W
Aug. 1	8.10 a.m.	...	...	...	...	...	...	...	...
,, 1	5.53 p.m.	...	...	...	...	...	...	...	...
,, 1	7.5 p.m.	...	...	...	...	...	...	...	...
,, 2	5.34 p.m.	...	...	...	...	...	...	...	...
,, 2	7.30 p.m.	...	...	...	...	...	...	...	...

* Track charted on Fig. 1.

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miles); and a number of pilot balloons were observed with one theodolite; these balloons when filled to lift 85 grammes have a diameter of about 59 cm. (23·2 in.). Their rate of ascent, deduced from previous observations with two theodolites, is assumed to be 500 ft. per minute, and to remain uniform; up to the heights to which the small balloons were followed, 4 to 5 km. (2·5 to 3·1 miles), this assumption probably gives a fair idea of the wind velocities; in all cases during the week under discussion, larger rates of ascent would mean that the deduced wind velocities should be larger.

The table on page 46 gives the values of the wind velocities and the wind directions for all the ascents made at Ditcham Park during the international week.

The principal feature to notice is that there was a great change in wind direction between the first and the second day; on the 27th the wind was South-westerly; on the morning of the 28th at 9 o'clock the lower clouds, cumulus, were coming from the North, but the cirrus was still coming from the South, and was moving with a high velocity; by the evening, however, the Southerly current in the upper air had given way to a North-westerly current, and the wind in the upper air remained North to North-west for the rest of the week; on August 2 in the evening there was a shallow surface wind from the South, but above this the wind was from East of North.

DISCUSSION.

THE PRESIDENT said that had he not been in the chair he could not have resisted the temptation to make some critical remarks on one term frequently used in Mr. Cave's most interesting papers. It was, however, not the function of a chairman to take part in controversy, but he gave notice that after he had ceased to preside over these meetings he would raise his voice on the first occasion that the words "isothermal layer" were used in his hearing, and humbly request that some more appropriate adjective than "isothermal" be applied to a region where the temperature was permitted to vary from place to place and from time to time. He would ask those who had taken part in organising or carrying out meteorological work with kites or balloons to be good enough to give their opinion on the papers. As they were generally met with a considerable competition in modesty when the question of speaking first arose, and as it was impossible that every one should speak last, he would call upon them in alphabetical order.

Mr. R. M. BALSTON said that the kite which was exhibited would give some idea of the sort of work he had tried to do in that line. His object had always been to make a kite which would fold up easily and could be carried about. He had found that the plan of making them with wings like the model (shown overhead) was a good one, because with this system it was easy to produce any desired curvature of the lifting surface. He had, however, practically given up research, as far as kites were concerned, during the last two years, because of the small demand. The only Society making use of kites was the Royal Meteorological Society. It might be possible to get other Societies interested, so that more work might be found for kites. They might perhaps be used at sea. Man-lifting by means of kites was carried on by the army, and as fresh air could be got quite a little way up, perhaps doctors might in

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the future send their patients up into the air instead of to Margate. The Aeronautical Society had started a ground in Essex, where he hoped to have the pleasure of private competition with inventors of other forms of kites.

Mr. C. BROGDEN said there was not much more to add about his kite, after the able way in which Mr. Bruce had described it. Since it was flown at the competition it had been slightly modified by adding the front bridle-bar instead of the struts. This gave it vastly more strength, because the wings could be sustained in two, three, or more places. The bridle was attached to the end of the bridle-bar, and all the pull was along that bar. It would fly a much larger kite with the same weight. He considered that form of single-surface kite about the best, for the reason that each wing formed its own curve. He used to get out the curves in the air, by making a cloud of smoke and making small models glide through it to see the curves that the air took. He made each wing a certain size, and then gave half the distance of that wing to the next. This he found would fly much better. The average angle up to 5000 feet would be from 58° to 60°. The advantage of a flat kite was that it would fly with a very light breeze. With a breeze of 8 miles an hour the kite would rise very readily. It would also stand a wind of 40 to 50 miles an hour, and pull up 120 lbs. without varying its perpendicular position in the air. That kite and the box-winged kite had frequently lifted a man. On one occasion the box-winged kite broke away, but the other kite came down so gently that the man was not hurt. He would be pleased to meet any one in a competition to further the science of kite-flying. A good deal more use might be made of kites than was done at present.

Mr. W. H. DINES said he must thank Mr. Bruce for his interesting paper. No doubt a good deal more might be done to obtain a special kite for light winds, but at Pyrton Hill, as the other work did not leave time for more than a limited amount of kite-flying, they chose days on which there was a good wind, so that time might not be lost in getting up steam in the boiler for nothing and in vain attempts to start a kite. What they chiefly wanted was a kite that would be stable in any wind and never exert more than a certain definite pull upon the wire, because when heights of more than a few thousand feet were attempted there was often the risk of a very strong wind being met with which might make the kite unstable and break it, or might break the wire. Trials of kites on a preappointed day were not of much use; before one could pronounce definitely upon the merits of a kite it was necessary to have used it several times under all conditions of weather.

With reference to Mr. Cave's paper he thought the greater average height in 1908 was probably due to more experience. It was unusual to get a duplicated case, but it was noteworthy that most of the balloons sent up in the middle of the week showed duplicated traces; from which it appeared that changes of temperature occurring in a short time in the upper air were general over the country on July 28 and 29. Unless there were a great difference in the velocity or direction of the wind at different heights the instrument would rise and fall through pretty much the same air, so that he thought the double traces were due to changes of temperature of the air rather than to changes of place. With further experience he was becoming more certain of the general reliability of the results. On October 2 a balloon was sent up by Mr. Cave; it was found quickly, the trace worked up, and the result published. This balloon was sent up at 4.20 P.M. in a Southerly wind, and as Ditcham Park is south of Pyrton Hill, it drifted towards Pyrton Hill and was probably about 15 miles from Pyrton Hill when it burst. On the same day at 5 P.M. a balloon was sent up from Pyrton Hill, and it is obvious that relatively to the moving air its track must have been very near to that made by Mr. Cave's balloon. This was not found for some time. When the trace was worked up

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a curious kink in the curve was noticed, the gradient from 4200 metres (13,780 ft.) to 4850 metres (15,910 ft.) exceeding the adiabatic rate. It was supposed that a mistake had been made, but a fresh determination failed to show any mistake. The results for Ditcham Park were then examined, and precisely the same peculiarity, which had passed unnoticed at the time, was discovered. The results obtained last July, and also at the beginning of October, were not of the usual character; the temperature at the top was unusually low, and the commencement of the "isothermal" unusually high up. Mr. Cave's investigations as to the decrease of wind velocity at the level where the temperature gradient ceases were very interesting; there seemed to be good evidence that this was the case in July and also in the first week in October. Unfortunately the conditions did not always admit of following a balloon up to 12 or 13 kilometres (7½ or 8 miles). The change in the direction of the wind during the week noticed by Mr. Cave had also occurred at Crinan.

Dr. W. N. Shaw said they had not yet come to the end of the information they would get from the enterprise of the last week of July. He had received notice from an address in Fermoy, County Cork, that an instrument had been picked up in that neighbourhood. It had been seen for three weeks at the top of a tree, and had only just fallen down. Nobody knew when it had arrived in the tree. It had probably been there since the last week in July. Mr. Cave mentioned the possibility of an instrumental error in the records. This was a question raised most frequently by those who had the least experience of the instruments and methods of using them. Dr. Chree had already raised the question in *Nature*. He hoped the doubt would be set at rest by the examination of two instruments which had been placed at the disposal of the Laboratory for the purposes of experiment. Mr. Craig of the Egyptian Survey suggested in a letter that the idea of the isothermal layer (the stratosphere) was due to an instrumental error, based upon the fact that with aneroid instruments there was a certain lag in the record, because the metallic case did not respond to the variation of pressure instantaneously. Mr. Craig suggested that it was possible to explain all these phenomena by considering that the balloon went up to a certain distance and stopped rising, whereas the aneroid went on contracting after the balloon had come to rest. Apparent but not real isothermal conditions would be the consequence. These criticisms were really based by Mr. Craig upon his absence of knowledge of the methods of calibration. Mr. Craig had only seen one statement about the calibration of the instruments, and concluded that his explanation of the phenomena was not therefore inadmissible. A detailed account of the methods of calibration would probably convince him of the reality of the phenomena. As regards the part of Mr. Cave's paper dealing with the variation in the temperature of the stratosphere, there was one striking fact. The temperature in the line which the balloon took was the same. There was an apparent difficulty in explaining why the temperature was the same as regards the height as shown by the balloon, if it were not the same over long periods together or over a large area. But on further inquiry there was really more difficulty in explaining how a difference of temperature at different levels could arise in the stratosphere, than in explaining the persistence of isothermal conditions in vertical lines of the stratosphere in spite of the perturbations due to changes of pressure in the troposphere.

Mr. E. S. Bruce said that he was very glad to have heard Mr. Brogden's explanation of the additions to his kite.

Mr. C. J. P. Cave said that he thought the observations of balloons by means of theodolites up to the time of bursting disproved the suggestion that the isothermal layer might be only an instrumental effect due to the behaviour of the aneroid. When a balloon was watched its altitude above the horizon usually decreased as the balloon drifted away, but after a certain time it began

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to increase, and increased till the balloon burst; it would be difficult to fit in these facts with the above suggestion. Prof. Hergesell, by placing the meteorograph under the air-pump at appropriate temperatures, imitated as far as possible the conditions of an actual ascent, and could probably throw light on the question. Since the July ascents three more balloons sent up at Ditcham had been watched till after they entered the isothermal layer; in every case there was a decrease of wind velocity similar to that noticed in the July ascents.

THE PRESIDENT said that all present would wish to concur in expressing a vote of thanks to the authors of the papers, and also to those who had taken part in the discussion.

The Green Flash.

The following account of an observation I made some weeks ago may be interesting, because it was another example of the way in which the so-called "Green Flash" may be produced.

On September 5 I was travelling by railroad from Bristol to Folkestone. Between Ashford and Folkestone I happened to look out of the carriage in which I was seated. The sun was approaching the horizon; in front of its disc there was a bar of dusky cloud between the stratus and cumulo-stratus type, dividing the disc into three nearly equal parts. The lower portion was orange-red, the upper whitish-yellow, the middle covered by the bar of cloud.

As I looked I observed that a bluish-green flash (as it might be called) overspread the upper part of the sun's disc, and remained visible for some seconds.

This appearance could not possibly have been caused by refraction, and must have been an example of *simultaneous* physiological contrast.

It may be illustrated by the following experiments described in Goethe's work on *The Theory of Colours*, vol. 1, paragraphs 56, 57, and 79 (Eastlake's Translation), which are also examples of simultaneous contrast:—

"If a piece of white paper is placed on a yellow wall, the white paper will be overspread with a violet hue.

"Seen through an opening in a red or green curtain, objects outside appear to be tinged with the demanded or opposite colour.

"Let a white paper blind be fastened inside in front of the window on a winter evening; in the blind let there be an opening through which the snow of some neighbouring roof may be seen. While it is still to a certain extent twilight outside, let a light be brought into the room, the snow seen through the opening will then appear perfectly blue, because the paper is tinged with yellow by the candle light. The snow seen through the opening is here equivalent to a shadow illumined by a contrary light, or, if you please, to a grey disc on a yellow surface."—R. C. CANN LIPPINCOTT, Over Court, Almondsbury, Bristol, *November* 6, 1908.

Scottish Meteorological Society.

A General Meeting of this Society was held in Edinburgh on December 1, 1908, when Sir Arthur Mitchell read a paper on "The Obedience of Scarlet Fever to Seasonal Influence in Scotland." The first election of Officers and Council under the new constitution of the Society also took place. The Officers are: President, Sir Arthur Mitchell, M.D.; Hon. Secretaries, R. T. Omond and E. M. Wedderburn; Treasurer, W. B. Wilson; and Meteorological Secretary, A. Watt.

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THE GERMAN AEROLOGICAL EXPEDITION FOR THE EXPLORATION OF THE UPPER AIR IN TROPICAL EAST AFRICA, JULY TO DECEMBER 1908.

By Dr. RICHARD ASSMANN, Hon. Mem. R.Met.Soc.
Director of the Royal Prussian Aeronautical Observatory, Lindenberg.

As an Honorary Member of the Royal Meteorological Society, I beg to send a short account concerning the Aerological Expedition of the Royal Prussian Aeronautical Observatory, Lindenberg, to Tropical East Africa during the months of July to December 1908.

The object of this expedition was the exploration of the upper air in the heart of a tropical continent, in the very middle of the equatorial belt. The large Victoria Nyanza, whose extent of surface equals the Kingdom of Bavaria, was considered not only the best, but the only spot suitable for the purpose of making kite and self-registering balloon ascents on board a steamer, thus affording the opportunity of increasing or lessening the relative velocity of the wind, the chief object, though, being the recovery of the instruments sent up by ballons-sondes.

It was intended also to contribute to the elucidation of a well-known important problem, the origin and interior structure of the monsoon winds of the Indian Ocean, whose influence upon precipitation in India, and the subsequent crops, is of highest theoretical and practical interest. It would also be very valuable in supplementing the exploration of the Atlantic trade winds, successfully carried out by Hergesell and the assistants of Teisserenc de Bort and Rotch on board the *Otaria*.

A committee of scientific men was formed for carrying out this project, who tried to obtain the necessary sum of £2500 from public funds. The equipment of the expedition had, however, to be prepared without any delay, as an agreement had been made with the International Committee for Scientific Aeronautics, to collaborate, if possible, in the international ascents of July 26 to August 1. As the equipment was complete and already shipped, and the workers ready to travel (accompanying the leader, Professor Berson, were Dr. Elias, formerly assistant at, and Mr. Mund, balloon-superintendent of, the Royal Aeronautical Observatory), it was very disappointing, indeed, to be informed unexpectedly, at the last moment, that the application for a special grant was refused. To draw back being impossible, I was forced to find a Mæcenas of science, and—I found several.

The expedition left Europe in the middle of June, and managed, after some little delay at Mombasa and Nakuru, to arrive, *via* the Uganda Railway and the lake, with all its cargo of windlasses, kites, balloons, chemicals, instruments, and personal equipment, on July 24 at Shirati in German East Africa, situated on the east coast of the Victoria Nyanza, in 1° 7′ S. lat.

The Observatory is deeply indebted for the courtesy and most helpful assistance which the expedition met with everywhere in England and in British East Africa. Particularly we must thank Dr. Shaw, the Director of the Meteorological Office, who did not cease to help us by letters and

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telegrams, visits and inquiries at the Embassy and the Colonial Office, with the utmost success, so that through his intervention the expedition was able to charter a convenient steamer on Lake Victoria, instead of another disabled one.

The Observatory is also largely indebted to the Colonial Office and to all the authorities, Imperial as well as local, in British East Africa and Uganda. The members of the expedition beg to express their feelings of sincere gratitude to the officials of the Uganda Railway, and to the Custom and Port officers of the steamers plying on Lake Victoria.

During the period from the end of July until the middle of September, 23 ascents of self-registering balloons were made on the lake, of which 15 were recovered with their apparatus, and registered curves of pressure, temperature, and humidity of the air, some of the instruments reaching to very great altitudes. Eight instruments were lost, chiefly owing to the unknown difficulties in the management of india-rubber balloons, several of which burst in the air before the descent was finished, and on account of the lack of speed of the launch *Husseni*, belonging to an Indian merchant, Allidina Vishran, from Entebbe, and chartered for two months at a cost of £5 per day. With good fuel from Entebbe she could only run 7 miles an hour, which is, as a rule, insufficient for an effectual hunting of wind-driven floating balloons; and this was still much more the case when, with poor fuel from Shirati, she reached a velocity of only 5 to 6 miles per hour. With a speed of some 12 miles an hour the Victoria Nyanza may be considered the best place in the world for sounding-balloon ascents, because the winds generally are feeble enough to permit the recovery of nearly all the balloons sent up.

In the two highest ascents of these balloons, viz. to 65,000 feet and 56,000 feet (19,800 and 17,000 metres), there was found the most interesting "upper isothermal layer," first discovered simultaneously by M. Teisserenc de Bort and the writer, and afterwards pointed out in America by Mr. Rotch; and not only in nearly all countries, but also above the Atlantic Ocean between the Tropics and the Arctic Seas. It was *not* reached in the actual equatorial belt by the *Otaria* Expedition, and thus has been for the first time discovered through our ascents over continental East Africa in the corresponding latitudes, which is certainly a feature of great importance.

Equally interesting is the great average decrease of temperature with the altitude found over Lake Victoria; the lowest temperature encountered at 65,000 feet (19,800 metres) was − 119° F. (− 84° C.), the thermometer pointing to 79° F. (26° C.) on the ground (3800 feet = 1150 metres altitude above sea-level). The variability of temperature in the very high strata, well known over Europe and America, was found to be nearly the same amount over equatorial Africa; in two subsequent ascents at 56,000 feet (17,000 metres) − 105° F. (− 76° C.) and − 62° F. (− 52° C.) were registered, while the whole annual variation on the ground does not exceed 3 to 4 degrees C.

In addition to these registering balloons a large number of smaller pilot-balloons, carrying no apparatus, were sent up, partly soaring up to enormous heights, in order to complete the exploration of the wind. Their flight was observed with theodolites from fixed points on the shore. The most surprising result was the discovery of an uppermost current of air blowing

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nearly from due *West*, and flowing above the regular *Easterly* current of the equatorial region. The lower strata, underlying the regular Easterly trade, were swept by diurnal and seasonal winds, particularly by the sea and land breezes generally prevailing up to the height of 3000 to 4000 feet above the level of the lake.

The exploration of the sea-breeze was carried out by means of kites which could not be raised to greater altitudes, because there was a nearly calm stratum over the breeze, and the steamer was not powerful enough to produce a sufficient artificial increase of wind velocity.

As kite ascents formed an important part in the plan of the expedition, it was very detrimental not to find sufficient wind on the big lake. Professor Berson therefore tried to find it on the opposite westerly shore, making perhaps the first crossing of Lake Victoria. He sailed to Bukoba, and made on the way several soundings of the depths in the middle of the lake. The interior region proved to be devoid of islands and uniformly deep. But nowhere did he encounter a current of air strong enough to raise kites, except in connection with thunderstorms or heavy rain-gales; after having gone in vain to Entebbe, he returned six days later along the equator to Shirati.

The charter of the steamer having expired, the last week of September and the beginning of October were devoted to simultaneous ascents on the coast, where stronger wind could be expected, with kites and pilot-balloons, and on the borders of the Victoria Nyanza, where Dr. Elias remained for a couple of weeks and made a series of pilot-balloon ascents, no kite-work being possible. During this period Prof. Berson and Mr. Mund made 5 higher kite and 11 pilot-balloon ascents at Mombasa, and at the same time Dr. Elias carried out near Shirati 13 pilot-balloon ascents, mostly very high.

After this Prof. Berson and Mr. Mund went to Dar-es-Salaam, where they carried out, first alone and subsequently in collaboration with Dr. Elias, numerous ascents of kites to heights of 6560 feet (2000 metres), and of pilot-balloons, one of which reached the enormous height of some 66,000 feet (20,000 metres), went with the Easterly trade to 13,000 feet (4000 metres), returned to the east in the higher stratum of 26,000 to 33,000 feet (8000 to 10,000 metres), and again to the west in the uppermost elevation. Part of the kite-work was carried out on the ocean south of Zanzibar, on board the little Government steamer *Rovuma*. Several of these higher ascents, some exceeding 10,000 feet (3000 metres), were made at the end of October in the period between the two monsoons, and the others in the first days of December, when the North-east monsoon was blowing steadily.

At first it was intended to start in November simultaneous research on the continental coast and on the monsoon system of India by making kite ascents on the Seychelles Islands; but this plan had to be given up for meteorological and practical reasons, and was replaced by another one.

Prof. Berson and Mr. Mund availed themselves of the welcome opportunity of going on board the small German cruiser *Bussard* to the south as far as Delagoa Bay, to carry out some ballons-sondes ascents to 43,600 feet (13,300 metres) and kite ascents to 10,500 feet (3,200 metres) from the ship on the ocean and in the bay of Inhambane, 24° S. lat., while

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Dr. Elias made simultaneous kite and pilot-balloon ascents at Dar-es-Salaam and on sea.

Of course it is not possible yet to give more than a brief summary of the meteorological results; but I believe there is no doubt that we may expect very interesting and important new data with regard to the circulation of the atmosphere in all layers, and to the vertical distribution of temperature and humidity over equatorial East Africa and the western part of the Indian Ocean and its shores.

On that account I hope that my brief contribution to the *Quarterly Journal* of the Royal Meteorological Society will be of interest.—*January* 31, 1909.

Frost and Ice Crystals.

Mr. W. A. Bentley, of Jericho, Vt., U.S.A., has made a study not only of snow crystals,[1] but also of the forms that occur among the frost, ice, hoar-frost, window-frost, and window-ice crystallisations. He has given a detailed account of the results of his investigation in the U.S. *Monthly Weather Review* for 1907, and this is illustrated by 274 beautiful half-tone reproductions of some of his photomicrographs. The types of crystals illustrated are—(1) Tabular hoar-frost; (2) columnar hoar-frost; (3) window-frost; (4) window-ice; (5) ordinary massive ice; and (6) hail. The illustrations show a wonderful variety of forms of crystals, and make the study a most fascinating one.

The Snowfall of December 29, 1908.

It is stated that the weight of the snow which fell on December 29 on the 105½ miles of roads and streets in the borough of Hackney was estimated approximately at 20,000 tons. The cost of the extra labour employed in clearing the snow away amounted to £708 : 13 : 6, extra cartage cost £250, and salt £121, making a total expenditure of approximately £1080 consequent on the snowfall. —In Holborn it was estimated that the total cost of snow removal in that borough amounted to about £1400. The numbers of casual men employed, in addition to the Council's regular workmen, in the work of clearing the streets in connection with the snowfall, were—on December 29, 695; December 30, 656; December 31, 281; and January 1, 63. The total amount paid in wages was £525, but the total cost of the removal amounted approximately to about £1400.—The cost of clearing the snowfall in Lambeth amounted to the sum of £2481 : 10 : 9.—The cost of removing the snow in the city of Westminster was nearly £5000.—At Greenwich the snowfall necessitated an expenditure of £679 : 18 : 10.

Showing how large is the cost of snowfall to the community when spread over a large area, at Slough, twenty miles from London, £78 : 2 : 7 was chargeable to the ratepayers (carting, £39 : 7s.; manual labour, £38 : 15 : 7), besides other sums paid by individuals for clearing roofs, etc. In the larger suburban towns, such as Croydon, Ealing, etc., still greater amounts have been spent on the removal of snow, without taking into account the expenditure of the provincial cities, and of the railway companies.

[1] See *Quarterly Journal*, 1903, vol. 29, pp. 223-224.

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PROCEEDINGS AT THE MEETINGS OF THE SOCIETY

November 18, 1908.

Ordinary Meeting.

Dr. HUGH ROBERT MILL, President, in the Chair.

CHARLES WILLIAM BARTHOLOMEW, Blakesley Hall, Towcester;
WALTER J. E. BIKER, Wheatlands Grove, Harrogate;
Miss F. H. ROUSE BOUGHTON, The Abbey House, Shrewsbury;
ERNEST H. CASEY, F.R.G.S., Thatched House Club, S.W.;
Lieut. FREDERICK COOPER, R.N.R., F.R.A.S., 131 Sutton Court, W.;
JAMES EDWARD CROMBIE, M.A., LL.D., Dyce, Aberdeen;
Mrs. J. H. FOSTER, The Mount, Witley, Surrey;
Commander JAMES OLDEN HATCHER, Freshfield, Liverpool;
YOUNG HEE, 18 Kennedy Road, Hong-Kong;
ANDREW J. HERBERTSON, Ph.D., F.R.S.E., 43 Banbury Road, Oxford;
THOMAS BROWN HEWETSON, Truro;
WILLIAM WAUGH LARKIN, 39 Aberdeen Walk, Scarborough;
ARTHUR LOCKWOOD, Beddgelert, North Wales;
Capt. DUDLEY R. W. PARSONS, 45 The Grove, Gravesend;
Capt. V. C. WHITE PARSONS, 138 Leadenhall Street, E.C.;
A. R. PILLAI, Trivandrum, India;
CHARLES EDWIN RIVERS, Assoc.M.Inst.C.E., Harrogate;
VINCENT IGNATIUS STEPHEN, Rangoon, Burma; and
WALLACE EDWARD WHITEHOUSE, 14 Gungrog Lane, Welshpool,
were balloted for and elected Fellows of the Society.

THE PRESIDENT, Dr. H. R. MILL, said that he had the honour of opening a new Session of the Society, and regretted that his first words must be a reference to the death of a distinguished Honorary Member, Prof. E. Mascart, the head of the French Meteorological Service, and for many years the President of the International Meteorological Committee. His work both in meteorology and magnetism gave Prof. Mascart the highest rank amongst men of science. He must also refer to the death of Mr. C. J. Bromhead, who was for many years observer at Lincoln, and had carried on a difficult series of investigations with an electrical thermometer fixed on the tower of Lincoln Cathedral. The Society itself had not been asleep during the interval since its last Meeting; its activity always continues, and a great deal of work had been done. At the last Meeting he had referred to several important delegations which were being set on foot by the Society. The most important of these was to have been the Conference of Meteorologists of the British Empire at Ottawa in July. He, Dr. Mill, having been appointed the delegate of the Society, had taken his passage and was prepared to start, when a few days before the date of sailing a cablegram arrived announcing that the meeting was postponed until next year, when it would be held at Winnipeg at the meeting of the British Association. He had received no further information, and there was a very short time now left in which arrangements for a meeting of representatives from all parts of the Empire could be made. Another celebration was the Semi-Jubilee of their sister Society in Germany, the Deutsche Meteorologische Gesellschaft, which was held at Hamburg at the end of September. Mr. H. Harries, who had represented the Society, would read his report that

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evening. The German Society was to be congratulated on the fine work it had done, especially in sharing with the Austrian Society the publication of the *Meteorologische Zeitschrift*, the most celebrated of all meteorological journals. The Society had also been represented by Mr. H. Mellish at Oxford on the occasion of the Jubilee of the Museum there, which commemorated the beginning of modern scientific study at that University. The other work of the Society had been carried on with due diligence. A very complete Exhibit had been sent to the Franco-British Exhibition, and it was satisfactory to know that it had been awarded the certificate for Grand Prize (the highest award) in both the classes of Education and Science. Arrangements had been made to provide and maintain a station in full working order during the period of the Exhibition, but as no ground had been set apart for this purpose, though promised, they were unable to do this. Such a station had, however, been fitted up at Newcastle, where the Society had also exhibited at the Annual Show of the Royal Agricultural Society, and this had proved a popular and interesting feature, useful in spreading not only a knowledge of meteorology, but also of the Society. Mr. W. Marriott, as the Society's Inspector, had visited various stations, and his report on these would appear in due course. Mr. Marriott was also, as the Society's Lecturer, continuing his lectures on meteorological subjects throughout the country, to various scientific societies and schools. The Society was taking an active part in the study of the upper air. Important observations were made in Ireland by Captain C. H. Ley, whose report would be laid before the Meeting that evening. They were also proceeding with the observations in Barbados.

The following communications were read :—

1. "German Meteorological Society.—Twenty-fifth Anniversary, 1908." By Henry Harries, F.R.Met.Soc. (p. 1).

2. "Investigation of the Electrical State of the Upper Atmosphere, made at the Howard Estate Observatory, Glossop." By W. Makower, Margaret White, and E. Marsden (p. 7).

3. "Balloon Observations made at Birdhill, Co. Limerick, during July and August 1908." By Capt. C. H. Ley, F.R.Met.Soc. (p. 15).

December 16, 1908.

Ordinary Meeting.

Dr. Hugh Robert Mill, President, in the Chair.

Paul A. Cobbold, M.A., Haileybury, Ontario ;
Thomas Curley, Public Works Department, Burma ;
John Somers Dines, B.A., 17 Larkfield Road, Richmond, Surrey ;
John A. Greenwood, F.R.A.S., Funtington House, Chichester ;
Henry H. Haines, F.L.S., Bovingdon, Herts ;
Neville Holden, F.R.A.S., Lindow Cottage, Lancaster ;
Frederick W. Nash, Hockley Heath, Birmingham ;
Sardar Nowrojee Pudumjee, Poona, Bombay Presidency ;
Tom Robinson, Town Hall, Hoylake ; and
Prof. Robert Wallace, F.L.S., University, Edinburgh,
were balloted for and elected Fellows of the Society.

Mr. J. W. Forrester and Mr. T. P. Newman were appointed Auditors of the Society's accounts for the year 1908.

The President, Dr. H. R. Mill, said that, before proceeding to the reading of the papers, he wished to refer to events in the history of the Society since

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the last Meeting. He regretted to record the death of one of the older Fellows, Mr. W. M. Beaufort, the bearer of an honoured name. He was the son of Admiral Beaufort, the originator of the famous Wind-Scale in use in this country, and he had himself served on our Council. The Council had passed a vote of condolence with Mr. Beaufort's relatives, and he was sure that the Fellows would share with the Council these feelings of regret. Several papers dealing with the subject which was now in the front of meteorological research would be read that evening. Mr. Eric Stuart Bruce had given a great deal of attention to the study of the means of attaining to great heights in the air with balloons and kites.

The following communications were read :—

1. "Some Forms of Scientific Kites." By Eric Stuart Bruce, M.A., F.R.Met.Soc. (p. 31).

2. "The Registering Balloon Ascents in the British Isles, July 27 to August 1, 1908." By C. J. P. Cave, F.R.Met.Soc. (p. 37).

3. "Balloon Observations at Ditcham Park, Petersfield, July 27 to August 2, 1908." By C. J. P. Cave, F.R.Met.Soc. (p. 43).

CORRESPONDENCE AND NOTES.

Lectures on Meteorology.

Mr. W. Marriott has recently given lectures on meteorological subjects, in connection with the Society's scheme for diffusing a knowledge of Meteorology, at the following places:—October 23, 1908, St. Lawrence College, Ramsgate; October 31, Christ's Hospital, Horsham; November 5, Wolverhampton Literary and Scientific Society; November 17, Uppingham School; November 21, Harrow School; and December 4, Tunbridge Wells Natural History and Philosophical Society.

Large Barometer.

We learn that Father Alfani has recently constructed at Faenza, the birthplace of Torricelli, the largest barometer ever made. The tube, instead of being filled with mercury, contains purified oil, rendered free from air, and he has thus been able to obtain a column 11·19 metres (36·7 ft.) in height, whereas with water the height would only have been 10·32 metres (33·9 ft.).

Madras Anemographic Records.

In the *Indian Meteorological Memoirs*, vol. 20, part 5, Mr. R. L. Jones contributes a paper on "A Discussion of some of the Anemographic Observations recorded at Madras." This contains an analysis of some of the wind records taken by a Beckley Anemograph at the Madras Observatory from 1865 to 1904, a discussion of some of the most prominent features of the air movements revealed by them, and of the relation of these to the general meteorological conditions over Southern India. The author found that there has been a progressive diminution in the recorded air movement, the mean daily movement for the first series of eleven years being 180 miles, for the second series 170 miles, and for the third series 156 miles. It is clear that the decrease was almost continuous up to 1887 and has since practically ceased. Recent comparisons with a Dines' Pressure-Tube Anemometer have shown that the scale of the instrument is correct. The position of the anemometer at Madras has never been changed, nor have any structural alterations been made in the building on which it is placed that could possibly affect the exposure. As alterations of this kind would show their effects by a sudden and constant

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change, and not by a persistent progressive one of the kind shown here between 1865 and 1887, it is evident that some slow change must have taken place in the surroundings, which continuously and increasingly affected the flow of air passing the anemometer.

As to the cause of this steady diminution in velocity, it seems most probable that the greater part, if not the whole of it, is to be ascribed to the change produced by growing trees. This explanation suggested itself to the author on seeing an old drawing of the observatory, where it was shown that the whole neighbourhood was then open and almost entirely free from trees to a considerable distance from the observatory. Even at present there are no trees very near and none overtop the instrument, but there can be no doubt that those in the neighbourhood do exercise a considerable influence on the air movement at the cups of the anemometer. Many of them were planted in the earlier part of the century, and have now attained their full growth. They have at any rate completely altered the character of the surroundings of the observatory and materially lowered the effective height of the anemometer, and this action was increasing for some time after the installation of the Beckley. Some support is given to this inference by comparing the air movements at the observatory and at the harbour, where the exposure of the anemometer is free and unobstructed on the east, the sea, side. The velocities at the harbour are as a rule considerably higher than those recorded at the observatory at the same time, especially when the wind blows from the sea side. Special tests and comparisons have shown that these differences are not due to the instruments themselves, and consequently they must be largely due to differences in the surroundings.

The daily variations of the air movement at Madras may be divided into three classes, viz.: (1) Those of the months November to February, which produce very little change in direction of the wind, and for which the variation curve is long and narrow, and almost parallel to the mean direction for the day; (2) those of the months March to April, which produce a considerable change in direction, not, however, exceeding five points; and (3) those of the months May to September, which produce a large change in direction of the wind, exceeding six points, and for which the variation curve is long and narrow, and almost perpendicular to the coast-line at Madras; the axis of the variation curve from west to east during May makes an angle of about 80° with the mean wind direction, and during June to September an angle of 105° to 120°. The daily variations in October are similar to those in September and form the most important part of the movement, but the means for this month combine data relating to widely different meteorological conditions, and their interest is chiefly climatological.

The following features are common to the diurnal variations in all months: (1) The variations during the day hours are much greater than during the night hours; the variation in the wind during the night hours in November to April is chiefly one of magnitude, the direction undergoing very little change; during the rest of the year, however, the variation at these hours is chiefly one of direction, the magnitude undergoing but little change; and (2) a sudden change in velocity occurs shortly after sunrise throughout the year; from November to February the change in direction is small, in March to April it is considerable, and in May to September it is large; throughout the year a rapid change occurs in the magnitude at this hour.

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RECENT PUBLICATIONS.

Handbuch der Klimatologie. Von Dr. JULIUS HANN. Band I. Allgemeine Klimalehre. Dritte, wesentlich umgearbeitete und vermehrte Auflage. Stuttgart: Verlag von J. Engelhorn, 1908. 8vo. xiv. + 394 pp. Price 13 marks.

In this third edition of his well-known Handbook of Climatology, Dr. Hann has revised and extended the former edition and brought the information up to date. The size of the page has been increased, and the book contains a copious index. This volume, which deals with general climatology, is arranged in six sections, and these are divided up into chapters and further subdivisions.

National Antarctic Expedition, 1901–1904. *Physical Observations, with Discussions, by Various Authors.* Published by the Royal Society. London, 1908. 4to. v. + 190 pp., 21 plates, and 2 maps.

This volume contains a series of reports on various portions of the Physical observations made during the voyage of the *Discovery* in the National Antarctic Expedition, together with other observations taken in different regions of the world in further illustration of the subjects under discussion. The Royal Society, having undertaken the supervision and publication of the Physical work of the expedition, placed the preparation of these reports in the most competent hands available.

The Tidal work of the *Discovery*, which was in charge of Lieutenant M. Barne, R.N., has been discussed by Sir George Darwin, who has also discussed the Tidal observations of the *Scotia*, which were entrusted to the Royal Society by Dr. W. S. Bruce, the leader of the Scottish Antarctic Expedition. The analysis of the *Scotia* observations has been furnished by Mr. Selby and Mr. Hunter.

The other Physical work of the *Discovery* included in the present volume, consisting of Pendulum observations, Earthquake registers, Auroral journal and Magnetic observations, was in charge of Mr. L. C. Bernacchi during the expedition, except the Magnetic work at sea, which was undertaken by Lieutenant Armitage. Engineer-Commander R. W. Skelton, besides his valuable contributions to the Photographic work, rendered much assistance in the Pendulum observations. All the officers of the ship, both scientific and naval, lent their help in the recording of Auroral phenomena.

The account of the Pendulum observations has been prepared by Mr. Bernacchi, and the discussion of these results has been supplied by Dr. Chree. Dr. John Milne has discussed the results of the Seismological observations, and compared these observations with others made contemporaneously in different parts of the world. Mr. Bernacchi has rewritten and arranged the Auroral journal, to which Dr. E. A. Wilson has contributed a series of striking drawings. The report on the Magnetic observations has been supplied by several contributors.

The Magnetic work of the *Scotia* was placed in the hands of Dr. Chree, who has discussed it in the present volume, while Mr. Mossman, who took the original observations, has furnished the account of the conditions in which they were taken.

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Solar Physics Committee. Monthly Mean Values of Barometric Pressure for 73 Selected Stations over the Earth's Surface. Compiled at the Solar Physics Observatory, South Kensington, under the direction of Sir NORMAN LOCKYER. London, 1908. 4to. v. + 97 + vi. pp. and 32 plates. Price, 6s.

A considerable amount of work has been done at the Solar Physics Observatory with regard to the possible relationship between solar and terrestrial changes. For this purpose the barometric changes at a great number of places scattered over the surface of the earth have been studied. The present volume contains those data, and also a set of curves made from them. The tables give the mean barometric pressure for each month for 73 stations, and for as long a period as the observations are available; one extends from 1833 to 1904, and another only from 1885 to 1899. In some of the tables the values are given in inches, and in others in millimetres. Some are reduced to sea-level, and others are not. The stations taken for the British Isles are—Stornoway, 1863-1904; Aberdeen, 1869-1905; Stonyhurst, 1885-1906; Armagh, 1869-1904; and Valencia, 1868-1905. It is pointed out that there is a remarkable relation in the nature of a "see-saw" between the changes of barometric pressures at Bombay and Cordoba, and that a similar variation holds good over large regions of which these places are centres.

The Atmosphere. By EDWIN J. HOUSTON, Ph.D. New York: Frederick A. Stokes Company. London and Edinburgh: W. and R. Chambers, Ltd. 1908. 8vo. 326 pp. Price, 3s. 6d.

This forms one of "Chambers's Wonder Books." It is a popularly written book on Meteorology, and is suitable for young people and also for home reading.

The Daily Normal Temperature and the Daily Normal Precipitation of the United States. By FRANK HAGAR BIGELOW, U.S. Department of Agriculture, Weather Bureau. Bulletin R., W.B. 395. Washington, 1908. 4to. 186 pp. Price, $1·75.

This contains tables giving the daily normal temperature at 177 stations, and the daily normal precipitation at 175 stations, in the United States.

Prof. Bigelow states that the temperature data contained in the report on temperatures and vapour tensions of the United States, reduced to a homogeneous system, gave the values for each month of the year, and generally for the period of 1873 to 1903. In the compiling of the climatological bulletins, which show a variation of the temperature and the precipitation for the current week, being published weekly, it is necessary to have normals which are available for any successive seven days which may occur in the year. For this purpose the monthly normals have been extended to normals available for each day of the year. In the case of the temperature this was accomplished by plotting down on a large sheet the monthly normals, drawing a curve through the twelve points representing the months, and then scaling off the temperature for each day. The monthly means were then taken from these values, and in case of any discrepancy between these monthly means and the original monthly normals, the curve was slightly adjusted, so that these two monthly means should be in very close agreement. The tables of the daily normal temperatures for the several stations, giving the temperature each day to the nearest degree, were obtained in this manner.

In forming the daily normals of precipitation, the procedure was of a different character. For each station all the records of precipitation for each

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day in the year were collected together, using the entire available series during which observations were made at a given station. The daily means of these data were taken, and the result of plotting these values in a curve shows that the record is by no means long enough to give a true normal value, the curve being generally rough and consisting of broken lines. This is due chiefly to the fact that occasionally the effect of a storm is to produce excessive local precipitation on the given date, but as the occurrence of this storm is more or less accidental at a given place it will require many more years of observations to eliminate this irregularity than we now possess. In order to approximate closely to the daily normal values which would be derived from a very long series of observations of precipitation, covering two or three centuries, it was thought proper to use the mean values of successive eleven dates—that is, beginning with January 1 to 11, inclusive, the mean precipitation was taken and entered against January 6; then taking January 2 to 12, inclusive, the mean precipitation for these dates was entered against January 7; and in this way the normal values were obtained for each day in the year. This smoothing process evidently tends to spread the excessive values of individual dates backward and forward through ten dates on each side of their occurrence, and this well-known process gives a very close approximation to the mean curve which would result from a very much longer series of actual observations.

In the cases of stations of short record, as compared with many stations covering thirty-three years, the following process was adopted for adjusting short records of precipitation to the corresponding long records.

A series of charts were prepared for every tenth day, as January 1, January 11, January 21, February 1, etc., on which were entered the values of the precipitation for every tenth day, using all the stations of long record, which covered the map of the United States quite fully. Then the values for each tenth day of the station with short record were compared with those in its neighbourhood, and such adjustments made as seemed to be justified. The daily normals were then interpolated between these 10-day values, in every case being guided by the trend of the corresponding daily normals of the neighbouring stations of long records.

These tables of daily normal temperature and precipitation are now in use in the climatological work of the Weather Bureau throughout the United States, and they have superseded all the daily normals which were prepared several years ago from much less extensive data than were available in the formation of these tables.

The King's Highway. The Nature, Purpose, and Development of Roads and Road Systems. By REGINALD RYVES, Assoc.M.Inst.C.E. London, [1908]. 4to. viii. + 96 pp. and 4 plates.

From the title of this book it might perhaps be supposed that it was altogether outside meteorology. The author shows, however, that the direct influence of climate upon both the construction and the maintenance of roads is very great. Severe frosts may heave up roads, prolonged droughts may reduce them to a loose and friable condition, rain and floods may wear furrows in the road-crust, cut away pieces from the edges, or even, by washing away all the binder, reduce the road to the condition of a sea beach. There are some influences of climate which can be met by good management at the time, and others, such as those of cutting winds, snow-drifts, and hot sunshine, which can be greatly lessened by intelligent road engineering.

With regard to the question of temperature changes, it is pointed out that a road overhung by trees, as well as one flanked by copses, is cooler by day and warmer by night in bright calm weather in the warm part of the year, and in

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clear radiation weather in winter is warmer by day as well as by night than bare roads. But the most important of the temperature changes which can be regulated by trees and hedges are those which take place in the neighbourhood of the freezing-point. In this respect the effects of trees and other growths are very important indeed. In dealing with the question of dampness in relation to trees, the author points out that during a large part of the year most trees are leafless, but this fact does not prevent their influence upon the temperature changes in the neighbourhood of freezing-point being considerable.

There are several ways in which, according to circumstances, protection from snow-drifts may be sought. When railways have to be protected from drifting snow by placing snow fences, the principle has been recognised that the fences should be placed at such a distance from the railway that the wind, after having its velocity checked at the fence, will regain, over the line, a velocity sufficient to sweep the snow before it. It is really a question of direction rather than velocity, but the necessity for leaving a space for the leeward drift is the same on highways.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of more general interest.

Abbot, Gen. H. L.—Progressive Climatic Variations on the Isthmus of Panama. *Monthly Weather Rev., Washington*, **36**, 1908 (163-165).

Anderson, J. A.—The Work of Prof. Carl Stormer on Birkland's Theory of the Aurora Borealis. *Monthly Weather Rev., Washington*, **36**, 1908 (129-131).

Barkow, E.—Zur Entstehung der Graupeln. *Meteor. Zeits., Brunswick*, **25**, 1908 (456-458).

Baschin, O.—Die klimatischen Verhältnisse der Stadt Berlin. *Zeits. d. Gesell. f. Erdkunde, Berlin*, **1908** (539-548).

Beals, E. A.—Annual Rise of the Columbia River in 1908. *Monthly Weather Rev., Washington*, **36**, 1908 (235-236).

Bell, L.—Note on some Meteorological Uses of the Polariscope. *Monthly Weather Rev., Washington*, **36**, 1908 (144-145).

Bigelow, F. H.—Studies on the Vortices of the Atmosphere and the Earth. *Monthly Weather Rev., Washington*, **36**, 1908 (245-250).

Bonacina, L. C. W.—Meteorology at the Franco-British Exhibition. *Symons' Met. Mag., London*, **43**, 1908 (126-128, 147-149, 174-177, 189-190).

Boutquin, A.—L'Asie centrale. Explorations et observations climatologiques. Son dessèchement. Le dernier voyage de Sven Hedin. *Ciel et Terre, Bruxelles*, **29**, 1908 (377-390, 401-412).

Chrystal, Prof. G.—On the Theory of the Leaking Microbarograph; and on some Observations made with a Triad of Dines-Shaw Instruments. *Proc. Roy. Soc. Edin.*, **28**, 1908 (437-460).

Colin, E.—Observations météorologiques faites à Tananarive. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (209-213).

Conger, N. B.—Ice Conditions on the Great Lakes, Winter of 1907-8. *Monthly Weather Rev., Washington*, **36**, 1908 (137-140).

Conger, N. B.—Storms and Ice on the Great Lakes. *Monthly Weather Rev., Washington*, **36**, 1908 (236-244).

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Dongier, R., and Brazier.—Dispostif expérimental, établi au Bureau central météorologique peur le contrôle des thermomètres au-dessous de 0°. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (185-186).

Gheury, M. E. T.—Further Observations of Halos and Coronas. *Monthly Weather Rev., Washington*, **36**, 1908 (256-259).

Grundmann, G.—Über einen einfachen Gewitterregistrator mit dem verbesserten Schreiberschen Nadelkohärer. *Wetter, Berlin*, **25**, 1908 (193-201).

Hopkinson, J.—The Weather of the Year 1906 in Hertfordshire. *Trans. Herts. Nat. Hist. Soc., London*, **13**, 1908 (221-240 and pl.).

Jochimsen,—Zur Geschichte der Meteorologie in der Provinz Schleswig-Holstein. *Wetter, Berlin*, **25**, 1908 (169-177).

Joester, K.—Die Föhnerscheinungen im Riesengebirge. *Wetter, Berlin*, **25**, 1908 (181-184, 203-206, 224-231).

Jones, R. L.—A Discussion of Types of Weather in Madras. *Indian Met. Mem., Simla*, **20**, 1908 (53-72).

Lacy, W. N.—Weather Influences preceding the Evacuation of Boston, Mass. [1776]. *Monthly Weather Rev., Washington*, **36**, 1908 (128-129).

Lacy, W. N.—Some Climatic Influences in American History. *Monthly Weather Rev., Washington*, **36**, 1908 (169-173).

Lagrange, E.—L'Électricité atmosphérique. *Ciel et Terre, Bruxelles*, **29**, 1908 (438-445).

Livingstone, Mrs. G. J.—An annotated Bibliography of Evaporation. *Monthly Weather Rev., Washington*, **36**, 1908 (181-186).

Lockyer, W. J. S.—In and above a London Fog. *Knowledge, London*, **5**, 1908 (223-224).

Mares, D. J.—Australian Weather. *Monthly Weather Rev., Washington*, **36**, 1908 (215-218).

Marilaun, F. K. v.—Untersuchungen über die Veränderlichkeit der jährlichen Niederschlagsperiode im Gebiete zwischen der Donau und nördlichen Adria. *Denkschriften der math.-naturwissen. Kl. der kais. Akad. der Wissenschaft, Vienna*, **84**, 1908 (53-110).

Mawley, E.—Report on Phenological Phenomena observed in Hertfordshire during the Year 1906. *Trans. Herts. Nat. Hist. Soc., London*, **13**, 1908 (241-248).

Meissner, O.—Die Luftbewegung in Potsdam (1894-bis 1900). *Meteor. Zeits., Brunswick*, **25**, 1908 (400-409).

Meteorology at the British Association. *Symons' Met. Mag., London*, **43**, 1908 (185-188).

Milham, W. I.—A Two Years' Study of Spring Frosts at Williamstown, Mass. *Monthly Weather Rev., Washington*, **36**, 1908 (250-254).

[Mill, H. R.]—The Thunderstorms of July 21 and 22, 1907. *British Rainfall*, **1907**. *London*, 1908 (20-35 and 3 pl.).

Moore, W. L.—Annual Report for the Fiscal Year ending June 30, 1907. *Monthly Weather Rev., Washington*, **35**, 1908 (Appendix, 1-19).

Moreno y Anda, M.—Observaciones magnéticas y meteorológicas en el Cerro de San Miguel, D. F. *Mem. Soc. Cient. Antonio Alzate, Mexico*, **26**, 1908 (305-351).

Obermayer, A. von.—Zwanzig Jahre meteorologischer Beobachtungen auf dem Ben Nevis. *Meteor. Zeits., Brunswick*, **25**, 1908 (385-396).

Omond, T.—The Range of Monthly Mean Temperature at Edinburgh, Vienna, and Stockholm. *J. Scot. Met. Soc., Edinburgh*, **14**, 1908 (231-237).

Peppler, W.—Zur Entstehung und Voraussage der Gewitter. *Wetter, Berlin*, **25**, 1908 (217-219).

Quervain, A. de.—Beiträge zur Wolkenkunde. *Meteor. Zeits., Brunswick*, **25**, 1908 (433-453 and pl.).

Quin, J. T.—A Hurricane in the West Indies in March 1908. *Monthly Weather Rev., Washington*, **36**, 1908 (136-137).

Russeltvedt, N.—Ein neues Haarhygrometer. *Meteor. Zeits., Brunswick*, **25**, 1908 (396-400).

Schiötz, O. E.—Bemerkungen über die durch den Wind erzeugten Meeresströmungen. *Ann. der Hydrog. u. marit. Met., Berlin*, **36**, 1908 (429-446).

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Schrötter, F. v.—Hebung der Kimm und Luftspiegelungen in der Nordsee. *Ann. der Hydrog. u. marit. Met., Berlin*, **36**, 1908 (490-497).

Schulze, P.—Ludwig Friedrich Kämtz. *Wetter, Berlin*, **25**, 1908 (178-181, 201-203, 219-224).

Seeley, D. A.—Windstorm at Peoria, Ill., May 5, 1908. *Monthly Weather Rev., Washington*, **36**, 1908 (187).

Seeley, D. A.—Studies in the Formation of Frost. *Monthly Weather Rev., Washington*, **36**, 1908 (259-261).

Smith, J.—The Relation of Rainfall to the Depth of Water in a Well. *J. Scot. Met. Soc. Edinburgh*, **14**, 1908 (225-230).

Spence, M.—The Climate of Orkney. *J. Scot. Met. Soc., Edinburgh*, **14**, 1908 (238-255).

Steffens, O.—Über einen neuen Apparat für die Registrierung der Windgeschwindigkeit (Normalanemograph). *Ann. der Hydrog. u. marit. Met., Berlin*, **36**, 1908 (513-515).

Stewart, Chas.—The Climate of Spokane, Wash. *Monthly Weather Rev., Washington*, **36**, 1908 (175-177).

Stilwell, H.—Returns of Rainfall, etc., in Dorset in 1907. *Proc. Dorset Nat. Hist. and A.F.C., Dorchester*, **29**, 1908 (143-152).

The Isothermal Layer of the Atmosphere (Report of Discussion at the British Association Meeting). *Nature, London*, **78**, 1908 (550-552).

Vanderlinden, E.—Les Pères de l'Église et la météorologie. *Ciel et Terre, Bruxelles*, **29**, 1908 (333-341).

Varney, B. M.—Early Meteorology at Harvard College. *Monthly Weather Rev., Washington*, **36**, 1908 (140-142).

Ward, R. de C.—Government Meteorological Work in Brazil. *Monthly Weather Rev., Washington*, **36**, 1908 (254-256).

Watt, A.—Rainfall Observations in Scotland. *Trans. Highland and Agric. Soc. of Scotland, Edinburgh*, **20**, 1908 (151-155).

Watt, A.—The Weather of Scotland in 1907. *Trans. Highland and Agric. Soc. of Scotland, Edinburgh*, **20**, 1908 (330-340).

Wedderburn, E. M.—The Freezing of Fresh-water Lakes. *J. Scot. Met. Soc., Edinburgh*, **14**, 1908 (219-224).

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PUBLICATIONS

OF THE

Royal Meteorological Society.

REPORTS OF THE COUNCIL. 1st, 1851, to 11th, 1861. Mostly out of print.

PROCEEDINGS. Vol. I., 1861-63, to Vol. V., 1869-71. Price £1 : 5s. each.

QUARTERLY JOURNAL. Vol. I., 1872-73, to Vol. XXXIV., 1908. Price £1 each. Quarterly Nos., 5s. each.

THE METEOROLOGICAL RECORD. Monthly Results of Observations made at the Stations of the Royal Meteorological Society, with Remarks on the Weather for each Quarter. By WILLIAM MARRIOTT, Assistant-Secretary. Price 1s. 6d. each. (Commenced 1881.)

HINTS TO METEOROLOGICAL OBSERVERS. Instructions for taking Observations, and Tables for their Reduction; together with a Glossary of Meteorological Terms. By WILLIAM MARRIOTT, Assistant-Secretary. Sixth Edition, Revised and Enlarged. With Illustrations. Price 1s. 6d.

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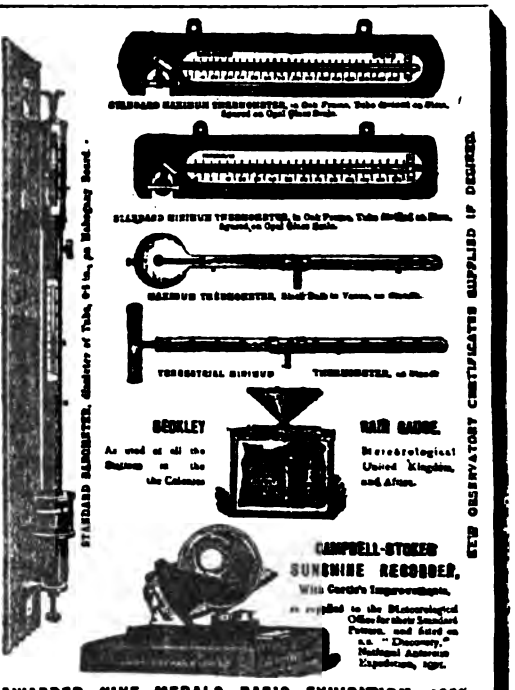
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SOME AIMS AND EFFORTS OF THE ROYAL METEOROLOGICAL SOCIETY IN ITS RELATION TO THE PUBLIC AND TO METEOROLOGICAL SCIENCE.

By HUGH ROBERT MILL, D.Sc., President.

[An Address delivered before the Royal Meteorological Society, January 20, 1909.]

IN this Address I do not propose to place before you a contribution to meteorological research, but to call attention to certain aspects of Meteorology in relation to the activities of the Society, and to daily life. The object of our Society is the advancement of meteorological science, and it is our business to consider the relations between that science and the public, as well as to forward the progress of Meteorology, and keep in touch with the work of meteorologists in all parts of the world.

While stating views to which I have been led by my experience as a Fellow of this Society for sixteen years and as a member of the Council for the rather long period of eight years, I claim no special authority by virtue of the office from which I am now about to be relieved, but accept full personal responsibility for what I have to say.

The Society is composed of Fellows whose interest in Meteorology varies widely, and there is moderation in dividing the Fellows into no more than three orders—meteorologists, observers, and interested persons. Meteorologists have either voluntarily devoted much time to the scientific study of atmospheric phenomena, or are professionally engaged in meteorological work; observers, while often well versed in Meteorology, specialise in collecting data and preparing them for discussion; and persons interested are those, and they form the majority, who have neither the special training of a meteorologist nor the special aptitude or inclination of an observer, but are none the less convinced of the importance of the work which is being done by the other two orders, and willing to support it, glad to become acquainted with the results

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obtained, able to follow and appreciate and often to criticise very usefully the expositions which meteorologists and observers lay before the meetings. The public contains many interested persons of this class who do not belong to a meteorological society, and are the less able on that account to understand what is going on in the air about them; but the great multitude of the public, which, for convenience, we may call the careless public, consists of persons who are not interested either actually or potentially in the scientific study of atmospheric phenomena, who require stimulus and education before they can think rationally or speak intelligently about the weather. Being uninstructed and not caring for the trouble of finding out what is already known, many of the careless public are ready to receive and adopt fantastic explanations of the weather, they are credulous of all dogmatic assertions on the question of long-period weather changes and predictions, but characteristically apathetic and sometimes antagonistic to the application of the scientific method or the expression of scientific results by responsible authorities. The natural recruiting ground for meteorological societies is amongst the interested public; but we owe a duty also to the wider circle of the careless public.

In dealing with the subject-matter of Meteorology there are two extreme points of view assumed by meteorologists which appeal to two opposite types of mind. These are the simply observational and the purely analytical. Where the former holds sway there is a tendency to look upon the accumulation of readings of instruments and detailed notes of weather changes as an aim in itself, though with no definite purpose of discussing and utilising them, or with the object merely of compiling tables of cumulative or mean values, and comparing one occasion with another. This spirit is most useful in its proper sphere, and may be highly developed in observers without doing any harm; it is indeed the good spirit of the observer, though at the same time it may be the evil spirit of the meteorologist, which blinds him to the higher objects of his work. The opposite point of view is that which takes interest only in the application of mathematical methods to sets of data, with the view of forcing them into conformity with certain relationships which may or may not have a physical basis. The danger for the type of mind addicted to this point of view lies in the tendency to make the method of treatment more important than the matter dealt with, just as in the parallel case of classical study exemplified by a great scholar who, when invited to criticise a sermon, found nothing worthy of remark save the improper pronunciation of a Latin word, which, as regards meaning, was quite appropriate. Hitherto the Society has shown no predilection for this extreme; our Fellows might even with advantage stand less far from danger in respect to it, and I mention it only in order to take account of both directions in which the pendulum may swing.

The extreme observational and analytical types of mind are not often sympathetic, and it is one of the advantages of a scientific society, for this antithesis runs through all science, to bring representatives of the two types together, and to encourage mutual toleration and understanding. At a time when the accumulation of data is the most important object to pursue it is well that the observational type of mind should predominate, for it is the most likely to deal critically with the accuracy

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of the observations to be discussed, and to secure that they should be of such a kind as to have a direct bearing on the elucidation of the course of natural phenomena. Observers are strengthened and encouraged when they are made to feel that it is on the foundation of their conscientious care that the whole fabric of science rests, and we may congratulate ourselves upon the fact that this Society has always given a high place to the observer, and has kept very prominently in view the fundamental importance of accurate observations. The analytical type of mind is undoubtedly that which, granted the completeness and the accuracy of the data, is fitted to carry Meteorology to its highest possibilities, to deduce the grand generalisations which unite and explain all details, and eventually to simplify the science by throwing essentials into a high light, and enabling the student to pass by matters of lesser importance. But no amount of mathematical treatment can draw sound conclusions from careless or imperfect observations, and in Meteorology, of all sciences, the organ-blower can compel the musician to say "we" instead of "I."

When the Society was founded, and for a good many years afterwards, the most useful field for its activity was the establishment of well-equipped and carefully inspected stations for accurate observations of meteorological phenomena. The system of stations has now been reduced to a routine, and it has fallen into line with the official systems of all the countries represented on the International Meteorological Committee. It no longer requires the expenditure of original thought to work it, and we may even imagine that the time might come when it would no longer require the fostering care of the Society at all. It was early understood, and has always been asserted, that the duty of the Society was to take up investigations in subjects otherwise neglected which were promising of good results. Hence throughout its history Committees have been appointed for the investigation of such matters as thunderstorms, lightning-conductors, wind-force, and research in the upper air. Personally I do not like Committees as agents of scientific work; but some Committees are more effective than others, and those of this Society have always proved themselves to be among the best. The natural function of a Society in the promotion of research is to seek for the most promising subjects which remain in want of special study, and, by calling attention to them, and encouraging research, to bring them prominently before the scientific world. I believe it would do most good by enabling some individual, with a natural bent for the subject, to take it up on his own responsibility, aided by the suggestions, guidance, and support of the Society. But whether through the exertions of an individual or of a committee, if it should fortunately prove that some line of research promoted by the Society opens out a field in which regular observations may be carried on for some application to practical ends—such as weather forecasting, or the like—the Society should, in my opinion, be proud that the field it opened has proved fertile, and turn with great encouragement to its search for "pastures new."

It seems to me, and I think that the history of our Society justifies my view, that the health of a Society profits by avoiding the deadly weight of routine which inevitably burdens any institution devoted to the detailed application of observations to purposes of practical utility, and by always retaining the power of reaching forward to what is new.

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There should in fact be constant movement in a Society's work. The free expansion of thought and the unfettered expression of opinion can only do good. Freedom from the trammels of public intervention or academic control is the most precious possession of a Society like ours. We are not bound to be the same to-morrow as yesterday in our efforts, though we can never change our aim. I believe that a specious error ably propounded by an enthusiast, and ruthlessly exposed and confuted by well-directed criticism, is a more useful subject for an evening meeting than a commonplace truth set forth without conviction, and languidly received. The Fellows should more often feel the spray of unknown seas as the ship of science plunges into a new world of investigation. We want our meetings to be stimulating, to suggest new ideas, to test our own understanding even of those statements that have been repeated so often as to make us feel from sheer familiarity with the phrases that we must know all about the subjects. It is no worthy ambition for our Society to pursue the even tenour of its way—the air is about us as it has always been, but every year brings some new mode of investigation, some fresh discovery which suggests a new point of view, or presents a new instrument of research. To the earnest student of Meteorology the highest purpose of the Society is to promote discontent with present knowledge, and the resolve to look again at old familiar facts in every new light that dawns. For the observer who takes pleasure, as every well-regulated mind does, in recording the conditions of the weather from day to day, it should be an intellectual treat to come here and learn to what great uses his observations are being put. To the speculating theorist it should be a help to learn from experienced observers that facts exist which contradict his views, or possibly that confirmation is afforded by data which he had overlooked.

But freely as I would admit all honest originality of thought, there is no room in such a Society as this for discussing the type of ideas, usually of doubtful originality, known to the scientific man as "paradoxes," ideas which originate in satisfied ignorance either of those fundamental principles of physics on which the whole science of Meteorology necessarily rests, or of those logical processes which are required for the very act of reasoning. It is not too much to ask of any one who yearns to propound a new theory to account for the nature or the order of any natural phenomenon, that he should first make himself familiar with the work of those investigators who have already grappled with the problem, and so far educate himself in the preliminary sciences as to understand something of their methods and results. Ignorance of the history of Meteorology and of the possibilities of Nature are at the bottom of most of the preposterous theories of cycles of weather whereby the showers and breezes of every day are predicted for all time, and for those perennial claims to regulation of the weather, bringing rain or dispersing fog, that every now and again trouble and disappoint the oversea dominions of the British Crown or the Mother-country itself. An even less excusable ignorance, that of the recorded weather of past years, leads to such absurd assertions as that the wireless telegraphy installations in Cornwall in 1903 brought about the very wet summer of that year.

I wish to make it clear that in disclaiming all sympathy with paradoxers and their methods, I do not deny the possibility of long-

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period weather prediction, nor the existence of climatic cycles or secular change, nor the utility of endeavouring to find some means of exercising control over atmospheric processes. I believe in the possibility of them all, and think it almost more foolish to assert that they can never be realised, than to declare that they have been. The scientific mind has in these latter days grown less dogmatic in negation than it was a hundred years ago. In the early part of the nineteenth century, the transmutation of the elements was laughed at as a vulgar error, a survival of the ignorant speculations of the Middle Ages, but now it is seen to be so obvious a possibility that no chemist would be greatly surprised if its accomplishment were demonstrated to-morrow. So, even if the desiderata of the weather prophets are, so far as we can see, still further in the offing than those of the alchemists, it is not unreasonable to expect that they may ultimately draw near with good tidings. Only they must be sought in the proper way, by the careful investigation of the laws which the actual movements and processes of the atmosphere exemplify. They are perfectly reasonable and proper subjects for pursuit, though, to the best of my belief, the pursuit of most of them will be long and unhappy to any one, who embarks upon it with no more than our present knowledge as a guide.

The control of the weather, similarly, is not impossible: on a small scale we control it every day, modifying the temperature of little detached portions of the atmosphere in our houses, modifying the relative humidity of the air of towns by the water-tight paving of our streets, dissipating fog in our dwellings by drying and filtering the air, preventing frosts in a garden or fruit-farm by erecting coverings or spreading a pall of smoke to check radiation, and relieving electrical tension by lightning conductors to prevent disruptive discharges. We have heard in the newspapers of the possibility of dispersing fog by electrical discharges ; we have felt when passing in the lee of a chimney whence steam is issuing, the artificial production of rain, and I have often been amused to see umbrellas raised in the belief that a shower was coming on. It would be absurd to assert that such things familiar on a small scale are impossible on a larger. The question is mainly one of scale and degree. From the practical point of view, it is necessary to inquire whether the cost of dispersing a fog by electricity or by filtering and warming the air bears any reasonable proportion to the advantage to be gained by applying the remedy. At present I think it does not, and research on the control of the weather must rather be directed towards finding a source of energy, conceivably in the atmosphere itself, which can be controlled or diverted so as to produce the desired effect. While this is true of one class of efforts to control weather, experiments which ignore the established laws of the conservation and transformation of energy can never succeed even by accident, hence the failures of the rain-makers up to the present.

I wish to call attention specially to two lines of usefulness which lie open to our Society at the present time. One is the correction of the impulsive sensationalism and anti-scientific spirit in meteorological matters of a certain section of the press of this country which no doubt faithfully reflects the somewhat muddled ideas of that body which I have defined as the careless public; the other is the advance which has been made in meteorological science during the last few years and the new opportunities

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it brings. The first indicates a practical service to the public which we can render with our present knowledge, the second points to promising lines of advance along which our knowledge may be increased. The press is fortunately a faithful exponent of popular feeling, and it is salutary, if sometimes a little depressing, for us to see through this medium the way in which scientific matters are viewed by that partially instructed person, "the man in the street," who too often is one of the careless public.

The subject is important, and I can illustrate it by one or two examples which have perhaps already passed from the mind of the public, but nevertheless point a moral which ought not to be forgotten. The first instance, fresh in my memory, is the attitude of some of the residents on the margin of Hampstead Heath towards the proposed establishment of a meteorological station on the summit of that splendid open space. The Hampstead Scientific Society, with the publicly expressed support of this Society, resolved to establish a second-order station on the Heath after having obtained the permission of the London County Council, who are the guardians of the Heath for the public, to place the instruments (and also an astronomical telescope in a small observatory) within the railings which surround the well-known flagstaff. The public have always been excluded from this small circular enclosure, and I believe it has sometimes been occupied by a fire-escape, which is probably both higher and more conspicuous than the modest telescope shelter. It was proposed to admit members of the Society to take the observations twice daily, and, with certain restrictions, members of the public were to have access by arrangement to the telescope at night. As soon as this proposal became known a few of the residents in houses looking out on the Heath attacked it bitterly. They pointed out that they had subscribed money to purchase portions of the Heath and to dedicate them to the recreation and amusement of the people; and they dreaded the creation of a privileged class trampling on public rights if the Scientific Society were allowed to have occasional access to the enclosure at present closed to every one. They shuddered at the disfigurement which the unsightly instruments would introduce into the view from their windows, some I fear even chuckled over the suggestion which they threw out to the Bank holiday revellers to use the sunshine recorder as a target for stone-throwing: they discovered that the County Council had no authority to sanction erections on the Heath, and they declared that they would not have the instruments there. The County Council closed the controversy by withdrawing its permission. The little episode is worthy of an earlier century. Curiously enough there is in the Golders Green grounds close to the Heath, and similarly dedicated to the public, a set of meteorological instruments which illustrates almost every possible error of exposure—the rain-gauge on a narrow frame 10 feet high, the thermometers under glass facing the reflected glare of sunlight from the panes of a conservatory—and no objection is taken to it, though it is far more conspicuous than a second-order station, and absolutely misleading to the public who consult its records as an indication of the state of the weather. No public objection has been taken so far as I know to the presence in some of the parks under the control of the County Council of rain-gauges of a type and set in a position which

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make it unlikely that they should yield correct records. Fortunately there is a prospect of a piece of ground being found under the control of an enlightened public body in close proximity to Hampstead Heath, and there I hope that the Hampstead Scientific Society will before long be able to carry out its excellent intentions. Had the observations been intended in any way for private gain or even for private enjoyment, the objection taken would of course have been perfectly sound; and I do not doubt that some of the opponents acted from disinterested motives. Nevertheless, while it is difficult to the verge of impossibility to raise from the general public a few hundred pounds for a scientific object, the project of a trustworthy station to be erected on public ground drew forth the promise of practically unlimited funds to be expended in opposition.

I could adduce other remarkable examples of the way in which the acquisition of meteorological data by public bodies has been hampered and even prohibited by another public body of higher degree; these have not become public, however, and I will not proclaim them, because of the deserved censure it would bring on institutions which we justly honour, on other grounds, from the people of countries where Science is more sedulously fostered by those in authority than it is with us.

I must allude more explicitly to a subject of a somewhat delicate nature, which is tending towards the public discredit of Meteorology. This concerns the popular errors current regarding published weather records, and the effect of these on the meteorological departments maintained by many municipalities. There seem to be popular notions that (1) sunshine is good; (2) rain is bad; (3) cold is bad; (4) dryness is good; (5) heat is good; and (6) to be above the local average in the "bad" elements, or below it in the "good," is a disgrace never to be acknowledged if it is possible to avoid it. So much is this the case, that I have heard of instances of reports being suppressed in order to obviate misconception, and of instruments being moved in order to obtain more agreeable records. I will mention no names, for it may be that repentance will come, and those who feel my criticism touch them need not be known unless they speak. In one instance, the grass minimum temperatures taken at a municipal observatory were not published in case they might give the public a false impression of the climate; in one instance a municipal observer was instructed by his Council to endeavour to find a site for the rain-gauge where the record would harmonise better with the low rainfall which was believed to prevail; in one instance a recording rain-gauge was set up not in order to find out how and when the rain fell, but to prove that most of it fell at night and only a little during the day. In one instance, a local Council held a discussion as to whether a photographic sunshine recorder should be procured to register more hours of sunshine than the Campbell-Stokes pattern hitherto in use; in that case the new recorder was established and recorded not a greater but a smaller duration than the standard instrument!

The fallacy underlying these and many other attempts at the suppression of truth, or the suggestion that accurate records are misleading, is that the healthfulness or pleasurableness of the climate of a place is determined by instrumental readings, or rather by popular

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opinion regarding them. Most of the favourite resorts in this country were discovered before instrumental meteorology was established, and they derived their reputation from the experience of visitors, not from tables of temperature, rainfall or sunshine. Thus the instrumental records tell us only what conditions exist in these pleasant places, and if we find that the records show a high rainfall, great extremes of temperature and little sunshine, they simply prove that those facts are powerless to affect adversely the health or pleasure of those who have found the place agreeable; although, of course, they also suggest that other places yielding similar instrumental results may be healthful and pleasant also.

In this country we can hardly have too much sunshine; but if high sunshine happens to be accompanied by, let us say, exposure to cold East winds, at the seasons when East winds blow, it may be that a cloudier spot with shelter from those winds is possessed on the whole of the more desirable climate, at least during certain months. That there should be an objection in the popular mind to a place where there is a great range of temperature is merely a proof of ignorance, for no temperature ever likely to be experienced in this country is so low as to be otherwise than exhilarating when the air is dry, and great extremes of temperature rarely occur when it is not. The dread of the popular fear of low temperature leading to a wrong view of climate is developed in a morbid degree in Canada, and the dread of a similar misconception from high temperature occurs in some parts of Australia. I have been rebuked by both Canadians and Australians for publishing the text of observations without a sermon on the superiority of the climates which they feared the ignorant might misunderstand. Humidity has more to do with the feeling of comfort or discomfort than temperature; but there are few statistics of relative humidity of any real value available for comparative purposes. The comparison of relative humidities at 9 a.m. or 9 p.m., or the mean of both, is most unsatisfactory, as those hours fail to take account of the great diurnal range of this element, and there are not many stations where observations are taken at an afternoon hour, or where a recording hygrometer is employed. The attempt to get an instrumental measure of the combined effect of warmth and moisture as it affects sensation has hitherto failed, and although such terms as "close," "relaxing," "bracing" have arisen to express differences which we can all feel, it is very difficult to estimate the degree of that feeling quantitatively. The courageous effort made by one of our Fellows, Mr. W. F. Tyler, to estimate *hyther* (the *hygrothermal* condition), while showing that one observer may succeed in establishing a scale of sensations similar in practice to the Beaufort scale of wind-force, does not establish the comparability of the estimates of different observers, and there is good reason to believe that the power of discriminating degrees of sensation differs widely in different individuals.

The popular fallacy about climate which appeals to me as one of the worst, so far as this country is concerned, is that a low rainfall is necessarily a thing to be desired and a high rainfall always a thing to be deplored. No doubt, wet days during a holiday are uncomfortable until one gets used to them, but from the point of view of public health

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dust and not rain is now recognised as the enemy. A rainy month in a large town is usually a healthy month, and by the advance of modern bacteriology, great stress is once more being laid on the immense value of rain as a purifying agent in the atmosphere, by carrying away the fine dust which consists in part of noxious micro-organisms, the germs of disease. It appears as if it might almost be said that places with low rainfall are healthful in spite of that fact rather than because of it. I can add, as the result of my own observation, that in places where the rainfall is normally high, a dry day reveals a beauty in colouring and a transparency in distant views of mountain or sea, that are never approached in the more dust-charged air of localities where the rainfall is normally low. Again, it does not follow that a place of high rainfall is necessarily a damp place, nor a place of low rainfall dry. Much depends on the slope of the land and on the nature of the soil. In mountainous country, or on limestone or sand, whether steep or flat, even a high rainfall quickly disappears from the surface, leaving the air dry, while in a level fen with clay subsoil the marshy surface holds water for months, and keeps the surface air charged with water vapour, though the rainfall may not greatly exceed twenty inches per annum. The exquisite beauty of a fine day in the Lake District, the West Highlands, or the west of Ireland, is unapproachable in any part of the country where there is a low rainfall, and where the air is scarcely ever purged of the finer dust which floats for weeks and dims all distant views. True, the fine days are fewer, but the duration of rainfall is not greater in the same proportion as the amount. Theoretically, we should expect that the rain-drops would be larger and the showers heavier and shorter in places where the air is more free from dust particles, than in those where a low rainfall leaves the air comparatively heavily loaded with solid matter.

It ought to be pointed out that the climate of a place as recorded by instruments may have a very narrow meaning. The readings of most instruments would differ widely between a station on the seashore facing south with an amphitheatre of white cliffs rising immediately behind, and a station on the top of a down 500 feet above sea-level open to all the winds that blow, though the two stations might be less than a mile apart. The climate of the place is represented badly by one or the other; to do it justice reference must be made to both. Yet there are people, shrewd enough in ordinary affairs, who suppose that if different records can be obtained from two points within a particular area, it is right to select the one which would yield results the more pleasing to the most ignorant members of the public, whose gauge of climate is largely prejudice. We do not want less instrumental observations, but more. If I were consulted by a public body as to the duty of a borough meteorologist, I should say that it was to investigate the climate of the borough, not that of one little plot of ground. A great deal could be done in this direction by having one fully-equipped station of the second order (in deference to popular carelessness which confuses second-order with second class, it has been proposed to change the international designation of stations) and several supplementary stations in localities carefully chosen to represent the different physical divisions of the area, each equipped with a rain-gauge, maximum and minimum thermometer,

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and a grass radiation thermometer. It would be easy for one observer to make all the necessary readings in succession, before or after the full series of observations at the main station. The necessity for reading punctually at 9 a.m. and 9 p.m. is not so great for maximum and minimum registering instruments as for those involving direct reading; but whenever it can be arranged it would be advisable to provide for the bottles in all the rain-gauges being changed at 9 a.m. *when rain is falling at that hour*, the contents could then be measured by the meteorologist on his arrival. If some such course were adopted, it would probably often be found that within the municipal boundaries there were differences of local climate due to different exposures as great as some of those which give rise to a lively rivalry between town and town.

When the honour of a town begins to be involved in its maintaining a lead in a certain element of climate, the honour of the local observer is apt to be subjected to a strain too heavy to be compatible with that equable mind which is necessary to good observing. While an observer with more zeal than conscience would be tempted to give the desired direction the preference in case of doubt, the opposite effect might be produced in an observer whose zeal and conscience were equally developed. In either case the result is unsatisfactory. A strain of this sort is only produced by the reflex action of popular ignorance, and it is one of our chief functions, as a Society, to spread enlightenment on these matters.

At a very early period in our history, in fact at the foundation of this Society, before the Meteorological Office took up the Meteorology of the land, we started with the object of establishing stations equipped with accurate instruments, and following uniform methods which should elucidate the climatology of England and Wales. Our quarterly *Meteorological Record* shows how much has been done in this way since, and Mr. Bayard's discussion of the accumulated data has deduced from them many valuable results. It may be that the time has come now to move onward, to take additional steps which may possibly prove as difficult now as the initial steps were half a century ago, but which should certainly not be more difficult. One of these steps might well be to secure new stations in the large areas of England and Wales where there are none at present, so as to obtain a nearly equidistant distribution of second-order stations over the country, and to increase the equipment of all stations by the addition of a sunshine recorder where that does not already exist. Another important step would be to secure an afternoon reading of the wet and dry bulb thermometers so as to arrive at a more definite knowledge of the variations in relative humidity both in time and space.

With this double purpose before us, the perfecting of the system of climatological stations on the one hand, and the spread of meteorological information on the other, we as a Society may hope to do a good deal towards the correction of the popular errors that still remain on the question of climate, and the careless modes of thought regarding meteorological matters. The efforts made by means of exhibiting a model observing station at Agricultural Shows and the gatherings of popular scientific societies, and the work of the Society's Lecturer have not been without result, and have helped in bringing about the improving tone which is now apparent. The daily and weekly press in most cases is intelligent and careful in its treatment of weather news. While a few

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papers still show regrettable credulity, or perhaps only carelessness, in putting forward the claims of paradoxers, and a few are over-anxious to announce that the weather of the moment is the worst or best in human memory, they all give prominence to accurate data when these can be secured. I am more struck every year as I examine the thousands of cuttings which reach me with the wonderful skill of journalists in avoiding innumerable pitfalls which beset the general writer when he enters on special matters, and with the really remarkable accuracy with which large numbers of figures are quoted. It is in no way an aspersion on the high character of British journalism, but a compliment to it, when I say that the papers show a failure on the part of the general public to recognise that the study of the weather is a branch of Science. A successful experiment in the classification of news items has been made in *The Times*, and it is interesting for a man of science to see Science lodged in one compartment with Art, Music, and Drama. It is somewhat humiliating to a Meteorologist to find that even the enlightened public to which *The Times* appeals (which probably contains a larger proportion of "persons interested" than is to be found amongst the readers of most newspapers) considers Weather an outcast from this select company, and most nearly akin to Shipping and Mails. We may be sure that this classification would not be repeated day after day unless the majority of readers felt it to be appropriate. We need not blame the public altogether for this view, for some men of Science whose special studies are too absorbing, have a tendency to look on Meteorology as a very poor and distant relation of the august family of sciences. Public and even scientific opinion does not yet see the anomaly of the absence of an official representative of this Society on the Boards of Visitors of the Greenwich and Kew Observatories, on which similar Societies associated with other branches of their work are represented, and the British Association will not allow the claim of Meteorology to have even a sub-section of its own in the annual meetings "for the advancement of Science."

I have said on another occasion that our Society has been too modest in its estimate of its own importance as regards the public. As the oldest, the most active, and by far the largest Meteorological Society in the world, possessing an absolutely unique and almost complete Library and Bibliography of Meteorological Literature, it should by this time have impressed its individuality upon the public of this country, as it has long since done on the scientific world beyond our shores. It requires to be better known in order to be better understood, and as it becomes better known and its Fellowship increases, its work will doubtless continue to improve with a growing acceleration, and the circulation of fresh blood in the Council cannot fail to enlist the fuller co-operation of all that is wise and strong and active amongst the students of the ways of the air.

I have said so much on the function of our Society in informing the public, and in spreading just views of climate and proper methods of considering weather, that little time is left for the second part of the subject—Our place with regard to recent progress and future advance in the study of Meteorology. We stand at a very important point in the history of Meteorology, which bids fair to expand in interest and importance in the twentieth century as Chemistry did in the nineteenth, and from the same cause—the increasing necessity of applying its principles

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to practical ends. It is plain that the standpoint of the meteorologist to-day is different from that of fifty or even of twenty years ago. Then the only department in which much general interest could be expected, or intelligent co-operation secured was Climatology, the study of the average conditions of the atmosphere at different places. Much remains to be done in that department; but the main interest is being diverted from the stratum of air four feet above the ground, on the study of which Climatology has been based, to the vast expanses of the upper atmosphere miles above the abode of man.

It has always been found that the satisfaction of the claims of practical utility has reacted powerfully on scientific research. I had occasion a year ago to refer to the important practical applications of a knowledge of rainfall, and our present knowledge of rainfall is to a large extent the result of the reaction of those applications. The science of Oceanography languished when only the surface of the oceans was utilised by mariners, but it shot ahead as soon as the necessities of cable-laying made exploration of the depths of the ocean a thing of practical moment. The work did not stop short when the requirements of cable-laying were exhausted; but cable-laying furnished the opportunity for renewed and extended research which has altered our conceptions of the economy of the ocean in Nature. The analogies between Oceanography and the Meteorology of the Upper Air are curiously close. In both, records have to be obtained by specially devised apparatus from a region beyond the reach of human life, and the special instruments devised by Mr. Dines for kite-work equal in the ingenuity of their adaptation any of those designed for oceanic exploration. In both, information regarding vast areas and volumes must be gathered from a small number of soundings which are often far from vertical. There is one fundamental difference between the two which tells in favour of the advancement of theoretical Meteorology by research in the upper air. In the depths of the ocean the circulation of the water and the propagation of heat throughout the mass is controlled by the solid walls of the hollows of the Earth's crust in which it lies, and the characteristics of fluid motion are most freely developed at the surface where they are most easily observed. In the atmosphere we ourselves live at the bottom where the influence of the solid land and the liquid ocean acts as a disturbance or control of the free movements of the air. Climate—the condition at the bottom—cleaves to the Earth, and belongs as much to Geography as to Meteorology. In the upper air the laws of gaseous motion have free play, being almost entirely withdrawn from the distorting drag of the Earth's superficial inequalities. The higher a kite or balloon ascends the simpler do the conditions become, and the more completely do theoretical laws apply to the actual state of matters. Geography is dropped altogether, and the Meteorology of the Upper Air belongs more and more to the domain of pure physics. The physicist has done a great deal towards the exploration of the free air, and our Society has been foremost in assisting the work; but, notwithstanding this, the great stimulus will come from the practical side. The past year has seen the possibility of aerial navigation fully established by the splendid achievement of Count Zeppelin and Mr. Wilbur Wright. In a few years the "airy navies grappling in the central blue," foreseen by the poet half a century ago, laughed at by

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caricaturists a hundred years since,[1] will demand a far more exact knowledge than is now required of atmospheric circulation, of the relation of wind to gradient, of the formation and dispersal of cloud, of the disturbing influence of insolation on pressure, of the nature and movements of atmospheric eddies and currents, and these things becoming of practical importance it will become worth the while of wealthy people to find the means for studying them.

At the commencement of an era in the study of the air which is certain to cause Meteorology to leap forward in public importance and in popular esteem, this Society will not allow itself to be left behind; and I have little doubt that by enlarging its views, which are not narrow, and adapting its methods, which are flexible, to the new requirements as they appear, it will continue to be the meeting-place of those engaged in advancing Meteorology by research, and of those who take interest in the advances and like to be in the forefront of expanding thought. Our great Library, were it only more worthily housed, should be the head-quarters of all literary work in Meteorology. I think that in almost all original papers on meteorological, and especially on climatological, research the references to earlier work on the same subject are too vague and few, making it difficult to estimate the proper place of new work in the historical development of the subject. It is possible that if we made ourselves better acquainted with the work of others we would write less; but we should certainly write better, and on more useful subjects. A good many papers read at this Society are incidental, that is, they deal with important incidents, such as a particular storm, a season of drought, or a prolonged frost, and as records such papers, when carefully compiled, have a real, though limited, value; but when these incidents are attached to similar incidents in the past, of which abundant records are preserved, the value is enhanced by the introduction of comparisons which may prove useful in many ways. Similarly with regard to the numerous papers recently published in the *Quarterly Journal* on investigations in the upper air, most of them would be improved by notes on earlier work, and by a statement as to how far the results obtained fit in with previous knowledge, and in what points they supplement it. The means for doing this are before us in the Library.

The Society has a place of its own and a purpose of its own in the scientific world, and it deserves to have a home of its own provided by the nation, as much as any of the Societies accommodated in Burlington House. But though able to stand alone in its independence, the individuality of our Society enables it to cultivate the closest relations with other bodies following kindred pursuits without rivalry save in mutual helpfulness. We live on the best of terms with our sister-Society in Edinburgh, and admire the courage and success with which it has faced the position created by the death of Dr. Buchan, who had been its life and soul for a generation. The reciprocal relations of the Society and the organisation of voluntary rainfall observers in the British Isles have always been intimate and cordial. These three are joined in unity of poverty; but good relations prevail no less with the Meteorological

[1] See reproduction of a French print of 1804 entitled "Divers projets sur la descente en Angleterre," frontispiece to *Symons's Met. Mag.* **43** (1908).

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Office, which spends the annual parliamentary grant for the acquisition, as well as for the application, of meteorological knowledge. We shall henceforth also have much in common with the University Lecturers in Meteorology, which the munificence of Professor Schuster has established in Manchester and Cambridge. Societies devoted to the theoretical and practical aspects of aeronautics will, we believe, find more to interest them in our work, and give us more hints as to the direction which meteorological research should take, with every year that passes.

We are proud of the position which the Meteorological Office has taken in the scientific world, and of the high recognition its Director has received on the part of the International Meteorological Committee. The public has learned from Dr. Shaw's address to Section A of the British Association at Dublin, a great deal regarding the more important scientific results which it has achieved, and although the history of those

> . . . . argosies of magic sails,
> Heralds of the purple twilight dropping down with costly bales,

which have alighted at 63 Victoria Street, left no time to refer in that Address to the other meteorological agencies of the country, I think it right to call attention here to the importance attached by the Meteorological Office to mutual co-operation. The new edition of the official *Observer's Handbook* will be issued with a statement on the title-page that it is "approved for the use of observers by the Royal Meteorological Society, the Scottish Meteorological Society, and the British Rainfall Organisation." Some of the rules for observers and specifications of instruments embodied in that work have been elaborated by this Society, and it is satisfactory, though of course not surprising, to find them incorporated with the rules securing international uniformity. I need hardly say that the eminently practical *Hints to Meteorological Observers*, prepared by Mr. Marriott, with the sanction of the Council, is not superseded; indeed, expressing, as it does, more than half a century's experience of the needs of English observers, it must continue to meet the want which the ordinary observer feels of simply-worded and adequate instructions.

Mutual co-operation between the various organisations which have a common interest in Meteorology must do good to the cause we have at heart, and it is to be hoped that it will not be confined to the *Observer's Handbook*. The saving which can be effected by preventing overlapping in the publication of statistics has often been pointed out and is fully understood, though of course it takes some time to adjust details in order that the mutual advantages may be balanced so accurately as to secure unanimous approval.

It has been said that Science knows no political boundaries, and this is true in the sense that we cannot ignore scientific work done in other countries, and published in other languages, simply because they are foreign to us. But there is another sense in which we may say that Science is not independent of political boundaries, for all civilised peoples must recognise the responsibility laid upon them to study the conditions and resources of their own country themselves, instead of waiting for some more intelligent foreigner to do it for them. Thus while we recognise the brotherhood of mankind by the creation of

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International Meteorological Conferences and Committees to ensure the study of Meteorology by uniform methods in all countries, we also realise the responsibility which rests on each country of seeing that the work is carried out thoroughly there. It would strengthen the hands of the meteorological observers in many British colonies, who are often inadequately supported and little considered by the local governments, or by the Colonial Office, if there were some form of co-operation with the Mother Country officially recognised and sympathetically carried out. Efforts in this direction were made some years ago by a Committee of the British Association, and although they have not yet had much result, it is to be hoped that the matter will not be allowed to drop. We had hoped that a great step forward would have been taken at the Conference called together by the Royal Society of Canada last July, but the meeting was postponed. The highly developed meteorological system of India, the extremely active service organised by Captain Lyons in the Sudan, the newly unified Australian system, the federal system of Canada, and the South African systems, which we hope soon to see unified also, are for the most part prosperous enough to stand alone for local purposes; but the tropical colonies of Africa, Mauritius, the small Atlantic colonies, and the West Indies are much in need of some fostering care, and if they could be included with the larger systems in an Imperial Meteorological Institute, Science would gain as much as the individual countries themselves. We like to look forward to a day when, in some great central building in London, all the meteorological agencies of the British Isles, and a central department for the Empire, would dwell together in co-operative independence; and I like to think that with the exercise of the principle of mutual concession, which has been successful hitherto, this splendid dream might ultimately be realised.

The aims of Meteorology and of the Royal Meteorological Society are, I repeat, not narrow, but as all-embracing as the atmosphere itself, and the efforts to fulfil those aims should be no less strenuous now than in the enthusiastic days when the Society was young.

Meteorology at Harvard University.

Prof. R. De C. Ward, in a paper in the *Journal of Geography* for January 1909, says that meteorology as taught at Harvard runs along geographical rather than physical and mathematical lines. The subject, therefore, finds its appropriate place in the Department of Geology and Geography, and the instruction deals very largely with geographical meteorology, or climatology. The principal end in view is to provide systematic instruction in the climatology of all parts of the world, with special reference to the relations of these climates to man. As at present arranged, the courses in meteorology and climatology are built up on an elementary half-course in meteorology (Geology B), and include, in addition, a half-course in general climatology (Geology 19); a half-course on the climatology of North America (Geology I.); a half-course on the

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climatology of South America (Geology 2), this being chiefly a geographical course; and a half-course on the climatology of the Eastern Hemisphere (Geology 3). These intermediate courses lead to research work in meteorology (Geology 20 *e*) and in climatology (Geology 20 *f*).

The elementary half-course in meteorology is required of all who take the more advanced work. In this first course a half-year is devoted to a study of the more important facts and theories in meteorology. Davis's *Elementary Meteorology* is used as a text-book. Four hours a week are devoted to laboratory work, which consists chiefly in the construction and study of weather maps and of meteorological charts and diagrams, practice in the use of the ordinary instruments and in the corrections of the observed readings, exercises in weather forecasting, and the like.

The climatology of North America (Geology I.) is a course designed to give a general view of the climates of this continent, especially suited to the use of students of physiography, forestry, and medicine. It is, however, intended to be a suitable course of instruction for those who wish a broad outline of North American climatology as part of a general education. Special attention is paid to the United States. As a part of the laboratory work each student constructs a series of charts and curves of temperature, rainfall, relative humidity, and cloudiness.

A course on the geography of South America (Geology 2) is on the border-line between physiography proper, economic geography, and climatology. To take it, students (except those in the Graduate Schools) must have passed in both elementary physiography and elementary meteorology. This course presents, in broad outlines, a general view of the physiography, commercial geography, and climatology of South America as a whole, and, in greater detail, of the different political divisions individually. Special attention is paid to climatology, and to the control of climate over habitability, occupations, travel and transportation, etc. The basis of the discussion is, first, the larger geological and geographical divisions, and then, in a subordinate way, the political divisions. This method lays the most emphasis upon the purely geographic provinces. The political divisions are considered in order that the course may meet the needs of those who may later have business relations with South America or may occupy consular or other official positions there. Laboratory work occupies 2 to 4 hours a week.

A course on the climatology of the Eastern Hemisphere (Geology 3) follows the same general lines as that on the climatology of North America, but the treatment is necessarily more superficial.

A half-course in general climatology (Geology 19) covers the ground of Hann's *Handbook of Climatology*, vol. i., and of Ward's *Climate Considered especially in Relation to Man*. This course is designed to give a knowledge of climatology in its broader aspects. It is recommended to those who intend to study medicine. Such subjects as the characteristics and hygiene of the zones, the acclimatisation of the white race in the tropics, the life of man under the climatic controls in the different zones, and changes of climate, are here studied.

Two research courses are given. One (Geology 20 *e*), a research course in meteorology, provides more advanced work in the subjects of courses 1, 2, 3, and 19, and is open only to those who have passed satisfactorily in those courses or who have had equivalent preparation. The other (Geology 20 *f*), a research course in meteorology, is given at Blue Hill Observatory. It is open only to advanced students who are thoroughly competent to take part in the special lines of meteorological investigation which are at present being undertaken at Blue Hill.

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THE COLD SPELL AT THE END OF DECEMBER 1908.

By WILLIAM MARRIOTT, F.R.Met.Soc.

[Read February 17, 1909]

THE weather during December was generally mild until Christmas Day, when a considerable change took place in the distribution of barometric pressure, and the weather assumed a wintry character.

The following extract from the *Monthly Weather Report* of the Meteorological Office gives a concise summary of the weather prevailing at the time :—

On Christmas Day the distribution of pressure underwent considerable modification, an Atlantic depression passing on to the Bay of Biscay, and the Continental anticyclone working round to northern Scandinavia, while the middle Atlantic anticyclone was expanding to the Spanish Peninsula. These Islands were thus in a belt of low pressure (extending from Iceland to the Mediterranean) separating two high pressures. Moderate temperature and very quiet dry weather were experienced in all parts of the Kingdom on the 25th, but on the following day the conditions gradually assumed a more disturbed appearance, the wind increasing from between South, South-east, and North-east, rain setting in in many localities, and temperature decreasing appreciably. In the course of the night of the 26th the conditions quickly became of a most wintry type. When observations were taken on the morning of the 27th, snow was falling in most parts of England and eastern Scotland, and temperature continued to give way. For four days the inclement weather was maintained, more or less snow being experienced except in a few localities in the extreme south-west and west. The conditions were aggravated on the 29th, on which morning a secondary disturbance appeared off the south of Ireland, and in the course of the day it was transferred to the Channel Isles and on to the north of France. Under its influence and that of the primary system (centred near Iceland) gales blew on many parts of our coasts, a strong Westerly gale at Malin Head, and from South-east at Donaghadee, a whole gale from South-east at Castlebay. At Deerness the anemometer registered a mean hourly velocity of 56 miles in an hour. With the high winds prevailing the snow was swept into great drifts in many places, and traffic by road and rail had to be suspended temporarily. In the circumstances it was difficult to ascertain what depth of snow fell on any one day. Aberyschan had 9 ins. on the 28th; next day Brighton had $5\frac{3}{4}$ ins., and Lewes $6\frac{3}{4}$ ins. In the four days, 27th to 30th, Llandrindod Wells had $11\frac{1}{4}$ ins., yielding 0·94 in. of water; Parkstone, Dorset, 1 ft., yielding 0·84 in. The snowfall at Aberdeen on the 27th yielded 1·3 in. of water, on the 29th at Stockbridge (Hants) 1·2 in., and at Watergate (Sussex) 0·8 in. In the far west very heavy rain fell on the 28th, with some snow or sleet locally. The largest measurements of water were 1·3 in. at Dundrum, 1·5 in. at Kilkenny and Waterford, 1·6 in. at Mount Callan (Clare) and at Falmouth, 1·9 in. at Penzance, and 2·1 ins. at Bray. At Falmouth an inch of rain fell in 3 hours 20 minutes on the morning of the 29th.

The snow, which fell on the 29th, was of a very dense character, and would not "bind." It therefore greatly interfered with traffic and locomotion. Some particulars respecting the cost of the removal of snow in London are given on p. 54 of the *Quarterly Journal.*

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Low Temperatures, December 28-30.

The most remarkable feature of the period, however, was the intense cold which prevailed over the central and south-eastern portion of England from the 28th to the 30th. This will be clearly seen from the maps of maximum and minimum temperatures, Figs. 1-5. These have been compiled from observations at about 200 stations, so they may be taken as fairly correct.

On the 28th the minimum temperature (Fig. 1) was below 20° over the central part of the north of Scotland and the central and southern portion of England; and was below 25° over practically the whole of Scotland and England, except the extreme south-west and west.



Fig. 1.



Fig. 2.

The maximum temperature (Fig. 2) during that day (28th) was below 25° over a considerable portion of the Midlands, and below 30° over practically the whole of England, except the south-west, and also in the south of Scotland.

On the 29th the minimum temperature (Fig. 3) fell below 15° over portions of Northamptonshire and Leicestershire, and below 20° over practically the whole of the inland portion of England (except the south-western counties) up to within about 20 miles of the coast.

On the 29th the maximum temperature (Fig. 4) was below 25° over practically the whole of England (except the south-western counties) and up to within about 20 miles of the coast, and remained below 30° over the greater part of Scotland, and the whole of England, except the south-west. In the extreme western portion of Cornwall the temperature was above 50°.

On the 30th still lower temperatures occurred (Fig. 5). Over a considerable area the minimum thermometer fell below 10°, and at

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several places the lowest temperature recorded was about zero, the lowest being – 1° at Liphook, Hants. Over the south and east of Scotland,



FIG. 3.



FIG. 4.

and practically the whole of England, except the south-west, the minimum thermometer fell below 20°.



FIG. 5.

Reproductions of the thermograph records kept by Mr. Edmund Lamb, M.P., at Borden Wood, Sussex, and by Mr. E. A. Lee, at Liphook,

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Hants, are given in Figs. 6 and 7. These stations are only a few miles apart. At the former the lowest temperature was 13°, but at the latter it fell to −1°. It will be seen that the lowest temperatures occurred between 6 and 9 a.m. on the 30th. The temperature then rose to about 26°, and fell to a second minimum between 5 and 8 p.m. After this the temperature rose rapidly, and the frost came to an end.

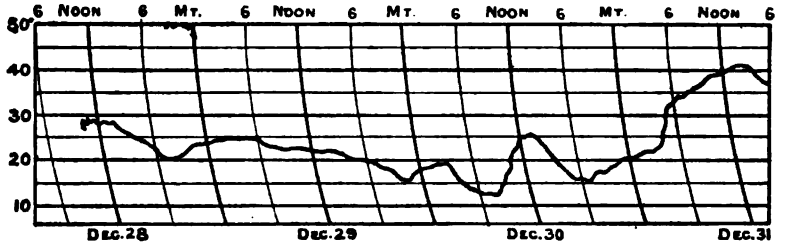


FIG. 6.—Thermograph Record at Borden Wood.

At most of the climatological stations the temperature at 9 a.m. on the 30th became the minimum for the next day, the 31st; while at the second order stations the minimum temperature for the 31st

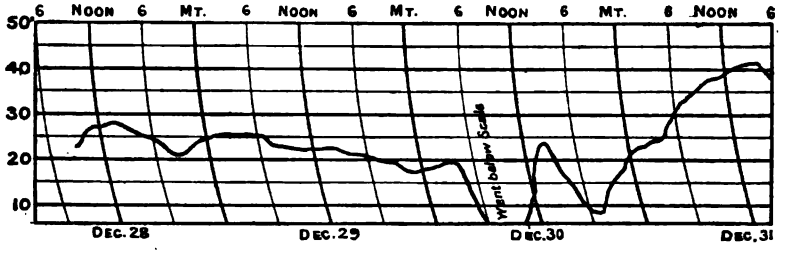


FIG. 7.—Thermograph Record at Liphook.

was practically the 9 p.m. reading on the 30th. As there is a considerable difference between these two sets of readings, it has not been considered desirable to reproduce the map of the minimum temperatures for the 31st.

DURATION OF INTENSE COLD.

The most striking feature of this cold spell was the length of time that the temperature remained below 25°. At Borden Wood the period was 60 hours; at Berkhamsted, Herts, 53 hours; and at Hodsock, Notts, 43 hours.

SUNSHINE AND RADIATION.

Fig. 8 gives the amount of bright sunshine recorded on the 30th; from this it will be seen that brilliant sunshine prevailed over the south and south-east of England and part of the eastern Midland districts. This shows that the sky was clear in those areas, and that it was cloudy or overcast in other parts of the country.

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Owing to the falls of snow, the grass minimum thermometers at most stations were covered up by the snow. At such stations, however, where

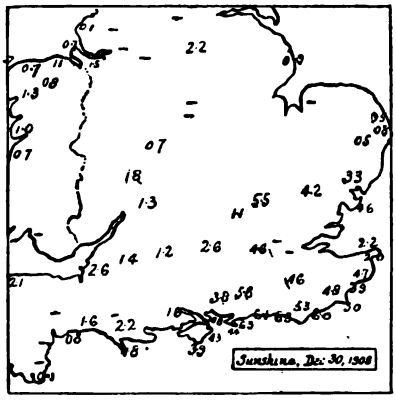


FIG. 8.—Hours of Bright Sunshine.

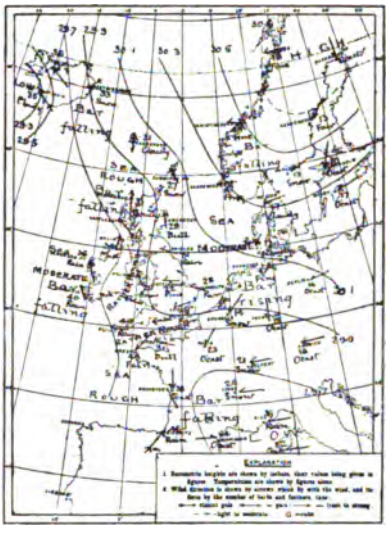


FIG. 9.—December 28, 7 a.m.

the observers placed the thermometer on the surface of the snow, very low readings were obtained during the night. The lowest readings

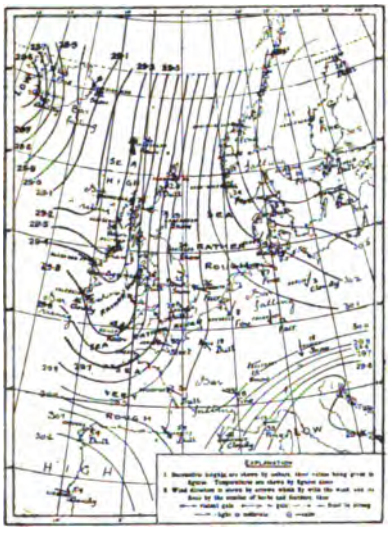


FIG. 10.—December 29, 7 a.m.

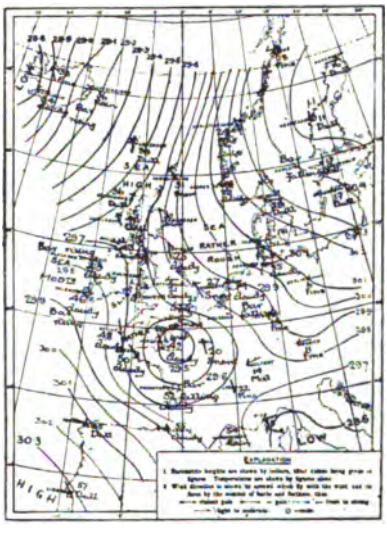


FIG. 11.—December 29, 6 p.m.

reported were − 8°·0 at Epsom, − 7°·0 at Raunds, and − 1°·9 at Tunbridge Wells. The temperatures on the snow were 10° or more lower than those in the Stevenson screen, the greatest difference being 16°·8 at

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Tunbridge Wells. This showed that there was great radiation. This was most intense in the same districts in which the lowest minimum temperatures occurred.

Atmospheric Conditions.

The isobaric charts for the period are reproduced in Figs. 9-13. These show that during the period in question there was a ridge or

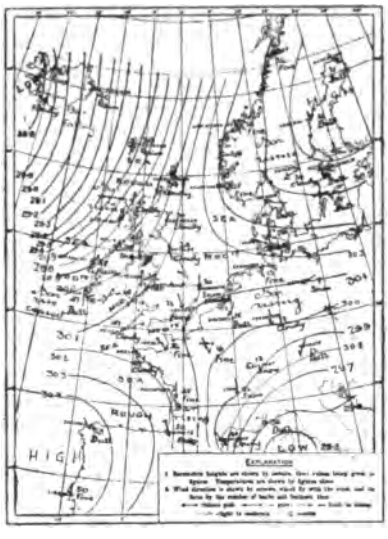


Fig. 12.—December 30, 7 a.m.

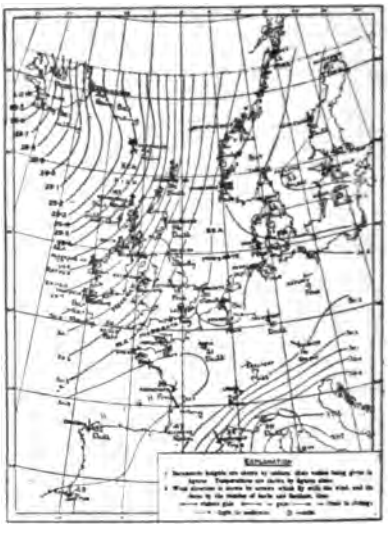


Fig. 13.—December 30, 6 p.m.

wedge of high pressure between two cyclonic systems, existing over the central and southern part of England, and that the conditions were thus favourable for the production of great cold.

The Hon. Ralph Abercromby and the author, in their joint paper[1] on "Popular Weather Prognostics" (which was read before the Royal Meteorological Society on December 20, 1882), were the first to call attention to the characteristic weather prevailing in a wedge-shaped area of high pressure, which is formed between a retreating and an advancing depression.

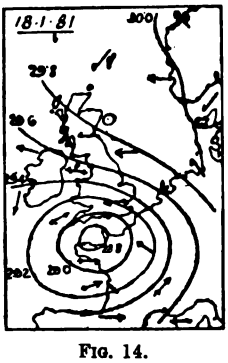


Fig. 14.

Similar Conditions in Previous Frosts.

It will be interesting to call attention to the fact that very low temperatures have been recorded on other occasions, when the distribution of barometric pressure was somewhat similar to that on December 29, 1908.

Fig. 14 represents the conditions prevailing on January 18, 1881, when a great blizzard occurred over the south of England. On the

[1] *Quarterly Journal*, vol. 9, p. 35.

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morning of that day a temperature of – 22° was registered at Blackadder in Berwickshire.

Fig. 15 shows the distribution of barometric pressure on February 11, 1895, when a temperature of – 17° was registered at Braemar, and – 11° at Buxton.

Fig. 16 shows the conditions prevailing on January 9, 1901, when

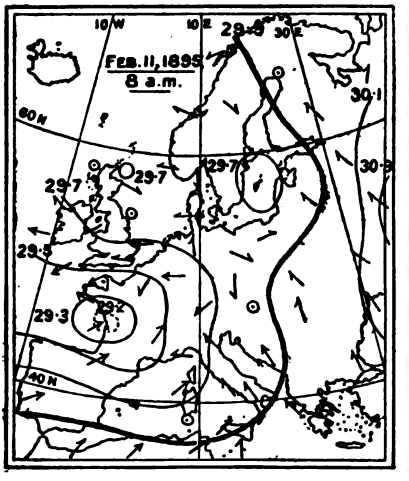


Fig. 15.

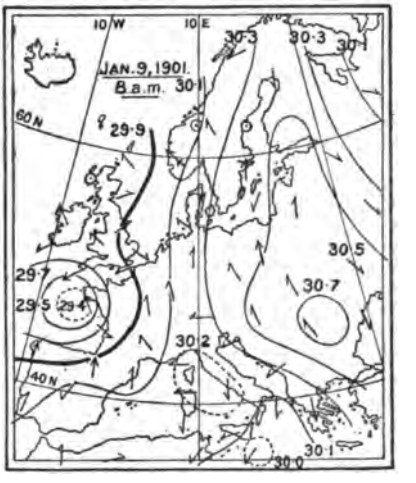


Fig. 16.

a temperature of – 1°·9 was registered at Swarraton, Hants. This is in the same district as Liphook, where – 1° was registered on December 30, 1908.

Previous Low Temperatures.

For the month of December the cold during December 1908 was very exceptional. The only instances in the neighbourhood of London or at Greenwich in which the maximum temperature was below 25°·5 for the day were the following :—

1796	25th	19°·5	1830	24th	22°·0	1890	22nd	23°·7
1798	28th	19·5	1855	21st	23·2	1908	22nd	25·4
1816	22nd	24·0	1874	31st	24·5	,,	30th	23·3

The lowest minimum temperatures recorded at Greenwich in the month of December have been the following :—

1796	25th	– 2°·0	1860	25th	8°·0	1870	25th	9°·8
1830	25th	10·5	,,	29th	10·0	1908	30th	12·1

The days with lowest mean temperature, since official records were commenced at the Royal Observatory, Greenwich, in 1840, are the following :—

	Mean Temp.	Difference from Average.
1841 . . . Jan. 8	12°·8	– 25°·2
1867 . . . Jan. 4	13·7	– 25·1
1894 . . . ,, 5	15·4	– 23·1
1908 . . . Dec. 30	16·6	– 22·3

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From the above remarks it will be seen that the cold of December 28-30, 1908, practically constituted a record for length of intensity over the central and south-eastern portion of England.

I have to thank Dr. W. N. Shaw, F.R.S., for permitting me to extract data from the returns in the Meteorological Office, and also for the use of the Weather Maps.

DISCUSSION.

Mr. W. W. Bryant said that there was one point that was not clearly shown in Mr. Marriott's diagrams, which was the effect of the climatological day ending at 9 a.m. Though a very low temperature was shown for Greenwich for December 31, there was actually no frost after 6 a.m. on that day, but the minimum thermometer being set at 9 a.m. on the 30th, when the lowest temperature was occurring, made it appear for the two days. With the exception of the period under notice, there had been no frost at Greenwich for the 60 days November 20 to January 20. On November 9 and 10 there was a severe frost, the most severe in the Greenwich records for so early in the season, or for the first frost in any season. The old readings quoted by Mr. Marriott were not official, but were probably just as reliable as the present ones. Taking the Greenwich official records there were 15 minimum temperatures, and 5 maximum, and 3 mean temperatures lower than those quoted by Mr. Marriott for December 30, 1908. The low reading on the ground on that day, 2°, was equalled on Christmas Day 1860, and the only lower reading was in 1845.

Mr. C. J. P. Cave pointed out the remarkable differences in temperature between the hill stations and those in the valleys in his neighbourhood. At Ditcham Park the minimum was 16°, at Petersfield 6°, and at Liphook $-1°$.

Mr. F. Druce said that in view of the tendency of the press to give its readers sensational reports concerning the weather, Mr. Marriott was to be thanked for placing the facts before them in an accurate and scientific manner. He (Mr. Druce) read an extraordinary paragraph from a leading London newspaper about the amount of bright sunshine in January 1909; it would be difficult to find out the meaning of the writer except by a process of subtle reasoning.

Mr. W. Marriott in reply said that he had confined his comparisons to the month of December only, although there had been greater frosts in other months of the year. He would like to urge on all observers to see that their minimum thermometers were graduated down to $-20°$, and that the dry and wet bulb thermometers were graduated down to zero. There were several instances where the thermometers could not be read, either because they were not graduated low enough, or else the mercury was hidden by the wooden bar supporting the tubes.

The President (Mr. H. Mellish) in conclusion said that Mr. Marriott's paper was a correlation of the facts, not only of this frost, but of the conditions under which frosts had occurred on several other occasions.

Mr. L. C. W. Bonacina, in a note to the Secretary after the discussion, wrote:—I think that the intense cold at the end of December was an example of how very low temperatures in this country occur when the ground is covered with snow. It is very rare that the temperature falls over a large area below 15° and approaching 0° without a covering of snow to intensify the cold of nocturnal radiation. When the sky cleared late in the evening of the 29th, after a heavy snowfall, the cold in the neighbourhood of London became intense, rendering

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persons out of doors for any length of time liable to be frost-bitten. On the morning of the 30th, when the weather was bright and sunny and intensely cold, the atmosphere appears to have been very dry. From such figures as I have examined in the Weather Report for December 30, the relative humidity seems to have been from 60 to 70 per cent in the south-east of England. This great dryness is difficult to account for. The ground was thickly covered with snow, and the North-easterly air was nearly calm—two conditions which would tend to keep the air near saturation; but to judge from the pressure chart, showing a wedge of high pressure over England, it is probable that the air was descending and being kept dry by the heat of compression.

Hail Insurance.

In the "Annual Report of the Department of Agriculture of the Province of Saskatchewan" for 1907, the following particulars are given respecting hail insurance:—

The Hail Insurance Ordinance is administered by the Treasury Department, and the following information concerning hail insurance for the year is furnished by Mr. John A. Reid, Deputy Provincial Treasurer.

During 1907, for the first time since Government hail insurance was instituted in the North-west Territories, a choice of rates per acre for premium and indemnity was offered to those taking insurance. Under the new plan of insurance it is provided that grain crops may be insured for either $3·00, $4·00, or $5·00 per acre, upon payment for full insurance of a fee of 11 c., 15 c., or 19 c. per acre respectively. Previously the maximum indemnity per acre for fully insured crops totally destroyed was fixed at the rate of $4·00, and the premium for insurance was 15 cents per acre.

The business done during the year was somewhat in excess of the transactions of the previous season; but the rate of increase was not nearly as great as is shown by a comparison of the figures for 1906 and those for 1905. The number of contracts for insurance was 1572 in 1905, 3464 in 1906, and 3930 in 1907. The area insured—483,255¾ acres—was about one-third more than was insured in 1906, and nearly two and one-half times the area insured in 1905. The proportion of the crop area insured was larger than in 1906; the proportion was slightly more than one-seventh in that year, and slightly less than one-sixth in 1907. In 1905 only one-eighth of the crop was insured.

The area damaged was 102,619½ acres. In 1906 the number of acres damaged was 39,147, or about two-fifths of the area damaged in 1907. The damage to the insured crops in 1907 was four times as great as in 1905, and the percentage of the insured area damaged was approximately twice as great as in either of the previous years. The number of claims for indemnity was 773, a large increase over the number in 1906, when 424 claims were made, and a still larger increase when compared with 258 claims made in 1905.

The season of 1907, therefore, affords abundant evidence of the practical utility of The Hail Insurance Ordinance in providing indemnity for the farmer whose crop is damaged by hail. During the year no less than 21¼ per cent of the acreage insured was damaged more or less, and the indemnity paid amounted to $167,411·30. The average indemnity per acre paid was greater in 1907 than in either 1905 or 1906. The figures are as follows—in 1905 $1·41, in 1906 $1·45, and in 1907 $1·63 per acre.

Owing to the fact that the percentage of the insured acreage damaged was about twice as great as in either of the last two years, the average indemnity paid per acre of the insured crop was also about twice the amount paid in other years. In 1905 the indemnity paid per acre of insured crop was 17½ cents.

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In 1906 the indemnity averaged 15½ cents, and in 1907 it was 34⅔ cents per acre. The cost of administration for 1907 was 2½ cents per acre, an increase of ⅛ cent per acre over the cost of administration for the previous year, and nearly 1 cent per acre more than for 1905. The increase on the cost of administration in 1907 was due to the fact that insured areas in several localities were visited by as many as three or four storms during the season, which necessitated an examination after each storm. Examiners' fees and mileage constituted no less than $7206·45 out of a total of $10,887·35 paid for expenses of administration.

The result of the year's work shows undoubtedly a desire for a higher rate of indemnity per acre. Of a total area of 483,255¾ acres insured for the year, only 18,514 acres were insured at 11 cents per acre, the new low rate, as compared with 207,347¾ acres insured at 19 cents per acre, the new high rate; the remaining 257,394 acres were insured at the rate in force for years, viz., 15 cents per acre.

It would appear, however, that these rates, high though they may seem to be, are quite inadequate, as the deficit for the year was no less than $101,543·54. So large a deficit per acre was exceeded only in Alberta in 1905, when they were confronted by a deficit of $27,779·80 on a total insurance of 62,634 acres. No less than 28 per cent of the insured acreage was damaged in Alberta in that year.

The Argentine's Antarctic Meteorological Station.

The corbetta *Uruguay*, of the Argentine Navy, left Buenos Ayres on January 14 for the meteorological and magnetical station at the South Orkneys. The relief party sent out by the Argentine Meteorological Office consists of four members, under the command of Mr. A Lindsay, of Edinburgh, who received his early meteorological training at the Ben Nevis Observatory, and who for the past year has been in charge of the new meteorological observatory established at Port Madryn, in the territory of Chabut. The observations at the South Orkneys this year are likely to prove of unusual interest and importance owing to the comparative proximity of the Charcot Expedition, which is to winter in the vicinity of Alexander Land. On the return voyage of the *Uruguay* a stop is to be made at Moltke Haven, South Georgia, in order to make magnetic observations in the same spot as that previously occupied by the German International Expedition of 1882-83. This work is entrusted to Mr. W. R. Bruce, chief last year at the South Orkneys station, who, along with the rest of the party, returns with the *Uruguay*. The data from South Georgia will be of great value in connection with the elaborate magnetic survey of the Argentine Republic and adjacent regions which has been in progress for some years, and which Mr. L. Schultz has nearly completed under the direction of Mr. W. G. Davies of the Meteorological Office.—*Scottish Geographical Magazine, March* 1909.

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Henry Storks Eaton.

1834-1909.

HENRY STORKS EATON was born at Little Bridy, Dorset, on October 30, 1834. He went to school first at Somerton, and afterwards at Dorchester Grammar School. In 1854 he proceeded to Trinity College, Cambridge, took his B.A. in 1857 and M.A. in 1860.

He became an assistant to Mr. Nathaniel Beardmore, a former President of this Society (1861-63) and a celebrated hydraulic engineer, at 30 Great George Street, Westminster, and collected a large number of statistics on rainfall and evaporation, which formed part iv. of Beardmore's *Manual of Hydrology*, 1862. In 1864 he was appointed Assistant to the Secretary and Librarian at the Institution of Civil Engineers, which post he held until his retirement on June 30, 1890. Although nominally Librarian, his work for the greater part of the time was that of editing, under the Secretary, the *Minutes of Proceedings*, which were enlarged to four volumes a year. He also took charge of the Students' Meetings, and Visits to Works, and generally superintended the affairs of that class when they extended beyond, or differed from, the privileges of the ordinary members of the Institution.

He displayed a keen interest in meteorological events even from childhood; and right up to the end of his life he could recall the changes of weather on given dates fifty or sixty years before. As early as 1849 he began making meteorological observations in a rough way. Subsequently he equipped a regular station at Little Bridy, and supplied, from 1857 to March 1864, monthly returns to Mr. James Glaisher for inclusion in his Meteorological Report in the Registrar-General's Quarterly Returns of Marriages, Births, and Deaths.

Mr. Eaton was elected a member of the British (now the Royal) Meteorological Society on March 24, 1857, and from the very first took a great interest in its welfare, and was a regular attendant at its meetings. The Society did not in those days possess an office of its own, so Mr. Beardmore gave the books house-room in his office. Mr. Eaton was appointed honorary Librarian in 1860, and during his occupancy of that post two Catalogues of books in the library were printed—the first of 12 pages in 1862, and the second of 14 pages in 1864.

He was elected a member of the Council in 1865, was three times Vice-President, became President in 1876-7, and remained on the Council, with the exception of one year, until 1888.

Mr. Eaton, with the co-operation of two or three others, was largely instrumental in inducing the Council to provide an office for the Society, and also to appoint a paid officer as Assistant Secretary. This was carried into effect on May 1, 1872, when a room was opened at 30 Great George Street. Mr. Eaton often called in at the office, and gave the Assistant Secretary the benefit of his advice. He took an active part in the "forward movement" in the Society, in the publication of the *Quarterly Journal*, and in the organisation of a network of second order stations. He urged that the stations should be regularly inspected by the Assistant Secretary.

During Mr. Eaton's Presidency, the Permanent Committee of the

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International Meteorological Conference met in London; and so he entertained the members of that Committee and the Council of this Society at a dinner which he gave at the Royal Aquarium on April 19, 1876, previous to the meeting of the Society on that evening.

Before vacating the chair at the Annual General Meeting in January 1878, he had the pleasure of announcing that the resolution "that ladies be admissible as Fellows of the Society" was carried. Miss E. A. Ormerod was proposed forthwith, and at the next meeting was elected the first Lady Fellow.

Mr. Eaton delighted in collecting and carefully discussing meteorological statistics. His principal compilations were on the average height of the barometer in London for 100 years, and on the mean temperature of the air at Greenwich from 1811 to 1856.

While living at Croydon he joined the local Microscopical and Natural History Club, and became President of the same in 1888-9. In his capacity of Secretary of the Meteorological Sub-Committee he prepared an elaborate report on the temperature and the rainfall of the Croydon district for the five years 1881-85. He also took a considerable part in the arrangements for the collection and publication of the tables of daily rainfall from a large number of stations in the Croydon district, which work has since been so ably carried on by Mr. F. Campbell Bayard.

After leaving Croydon, Mr. Eaton travelled a great deal for the benefit of his health, although he suffered from partial paralysis; but he made Dorchester his headquarters. He joined the Dorset Natural History and Antiquarian Field Club, and undertook to collect and discuss the returns of rainfall in Dorset, preparing the annual reports from 1896 to 1903. He also compiled elaborate reports on the annual rainfall 1848-92, and on the monthly rainfall 1856-95, the former accompanied with 2 maps showing the distribution of rain in the county and adjacent districts.

Whenever Mr. Eaton came to London, he always called at the Society's Office, and often referred to the returns from the various stations or to the daily weather reports. When possible he arranged his visit so that he might join the Council at dinner and attend the meetings of the Society.

He died at Ilfracombe on February 7, 1909.

Mr. Eaton married a daughter of Mr. Beardmore. She was an invalid for many years, and died in 1882. WM. MARRIOTT.

The Cyclonic Unit in Climatological Investigations.

At the meeting of the Association of American Geographers held at Baltimore, January 1 and 2, 1909, Prof. R. De C. Ward read a paper on this subject. He pointed out that climatology has been too much concerned with monthly, seasonal, and annual averages. These summaries, being based on final and definite periods, do not bring out the variations of the climatic elements under cyclonic and anticyclonic control, yet the irregular cyclonic and anticyclonic changes are the very ones which most affect man. An important addition to the usual climatic summaries would be the introduction, for all regions in which the cyclonic or storm control of weather conditions is characteristic, of the cyclonic unit, so that, for example, the average duration and value of cyclonic ranges of temperature in the several months, or the proportion of rain and snowfall received from cyclonic storms or from local thunderstorms, might be determined.

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REPORT OF THE COUNCIL

FOR THE YEAR 1908.

[Submitted to the Annual General Meeting, January 20, 1909.]

THE Council, in presenting the fifty-eighth Annual Report, have much pleasure in referring to the increasing interest in Meteorology which is apparent throughout the country, and they believe that this is in some measure due to the scheme of Lectures inaugurated by the Society. The Council observe with satisfaction the continued increase in the roll of the Fellows.

Amongst the losses by death the Council feel it right to refer specially to seven distinguished Fellows or Honorary Members who have done good service in various ways. Sir John Eliot, formerly Meteorological Reporter to the Government of India; Mr. R. J. L. Ellery, an Honorary Member, formerly Government Astronomer at the Melbourne Observatory, Victoria; Sir John Evans; Monsieur A. Lancaster, an Honorary Member, Director of the Meteorological Department of the Royal Observatory at Brussels; Prof. E. E. N. Mascart, an Honorary Member, formerly Director of the Central Meteorological Bureau of France; Prof. J. M. Pernter, an Honorary Member, Director of the Austrian Meteorological Institute; and Lieut.-General Sir Richard Strachey, third recipient of the Symons Memorial Medal, formerly Chairman of the Meteorological Council.

Committees.—The Council have been materially assisted during the year by several Committees, which have been constituted as follows:—

EDITING COMMITTEE.—The President, Messrs. Campbell Bayard, Bentley, Inwards, and Scott.

GENERAL PURPOSES COMMITTEE.—The President, Secretaries, Treasurer, Messrs. Bentley, Inwards, Latham, and Shaw.

KITE COMMITTEE.—(To co-operate with other bodies for the promotion of the study of the upper atmosphere.) The President, Secretaries, Colonel Capper, Messrs. Cave and Curtis, and Captain Hepworth.

LOCAL SCIENTIFIC SOCIETIES COMMITTEE.—The President, Secretaries, Treasurer, Messrs. Bentley, Druce, and Captain Wilson-Barker.

OBSERVERS' HANDBOOK COMMITTEE.—The President, Secretaries, and Dr. Dickson.

REVISION OF BY-LAWS COMMITTEE.—The President, Secretaries, Messrs. Dines and Druce.

Co-operation with the Meteorological Office.—The arrangements under which certain meteorological data are supplied by the Society to the Meteorological Office have been continued during the year. At the request of the Director of the Meteorological Office, the Council examined the new edition of the *Observers' Handbook*, and after proposing certain modifications, to which effect has been given, agreed to have it stated on the title-page that it was "Approved for the use of Observers by the Royal Meteorological Society, in association with the Scottish Meteorological Society and the British Rainfall Organisation." This cannot fail to promote that uniformity in methods of observation which is essential to the successful co-operation of observers throughout the country.

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Revision of the By-laws.—A favourable opportunity having arisen for considering whether the By-laws needed revision, the Council have gone into the matter, and recommend (1) That By-law 4 be altered to read as follows: "At least three of the Council, as defined in By-law 2, shall be Fellows who have not served on the Council in any capacity during the year immediately preceding"; and (2) that in By-law 62 the word "decline" be substituted for the words "refuse or omit within a year." These proposed alterations will be placed before the Fellows at the Annual General Meeting.[1]

Howard Medal.—The Howard Medal, which is competed for annually by the Cadets of the Nautical Training College, H.M.S. *Worcester*, was won by Cadet Twyman for an essay on "Forecasting the Weather."

Lecture.—In response to an invitation from the Council, Dr. G. Hellmann, Director of the Royal Prussian Meteorological Institute, an Honorary Member of the Royal Meteorological Society, came over from Berlin for the occasion and delivered a Lecture before the Society on March 11, on "The Dawn of Meteorology." This is a subject which Dr. Hellmann had made specially his own, and the Lecture was much appreciated by a large audience.

Research in the Upper Air.—The Council have continued to promote the researches into the meteorological conditions of the free atmosphere by means of kites and balloons. The Kite work at the Howard Estate Meteorological Station of the University of Manchester, under the direction of Mr. J. E. Petavel, F.R.S., has been supplemented by ascents made during calm weather by means of a captive balloon, to the cost of which the Society has contributed. A report giving an account of the Balloon Experiments organised with the assistance of Sir Daniel Morris and carried out by Prof. J. P. D'Albuquerque and other gentlemen, in Barbados, on November 6 to 8, 1907, was read at the May Meeting of the Society. As Prof. D'Albuquerque and his coadjutors have agreed to carry out further and more extensive observations, the Joint Kite Committee have resolved to send out a supply of balloons, cylinders of hydrogen gas, and two specially constructed theodolites. Valuable and interesting results are to be anticipated from these observations on the drift of the upper atmosphere over the West Indies.

Captain Ley carried out some interesting experiments at Birdhill, County Limerick, for the Joint Kite Committee, during July and August. His report on these observations was read at the November Meeting of the Society. Systematic observations are carried out by Mr. Cave at Ditcham Park, Petersfield; by Mr. S. H. R. Salmon, at Brighton; and

[1] The By-laws which it is proposed to amend are:—

4. Nine only of the twelve Ordinary Councillors shall be eligible in the same capacity for the ensuing year.

62. Every paper which may be presented to the Society shall be considered as the property of the Society, unless there shall have been any previous engagement by the Council with its author to the contrary; and the Council may publish the same in any way, and at any time, that they may think proper. But should the Council refuse or omit within a year to publish such paper, the author shall have a right to copy the same and publish it under his own direction. No other person, however, shall publish any paper belonging to the Society without the written consent of the Council, signed by one of the Secretaries.

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also for the Meteorological Office by Mr. W. H. Dines at Pyrton Hill, Oxfordshire.

At the December Meeting of the Society, Mr. Cave gave the results obtained from the registering balloon ascents made at the various stations in the British Isles during the week of International Ascents at the end of July. The Council gratefully acknowledge the services of all the gentlemen who have taken part in the observations.

The Government Grant Committee of the Royal Society made a grant of £100 towards the expenses of these investigations. The British Association has reappointed its Committee.

Prize Competition for Teachers.—This competition, the particulars of which were stated in the last Report, proved very successful, 180 essays being received from teachers, 7 from pupil teachers, and 11 from children between the ages of 11 and 13. After the examination of the essays, the Council decided to award four extra prizes in addition to those announced. The names of the successful competitors will be found in the *Quarterly Journal*, vol. 34, pp. 153-154.

Exhibitions.—The Society was again invited to take part in the Agricultural Education and Forestry Exhibition in connection with the Show of the Royal Agricultural Society, which was held at Newcastle-on-Tyne from June 30 to July 4. A large collection of instruments, photographs, diagrams, and maps was exhibited, and attracted a great deal of attention on the part of the visitors to the Show. The Council feel that such exhibitions bring the claims of Meteorology and the work of the Society before a large number of people in different parts of the country, who are likely to profit by the opportunity presented to them. The Society also contributed a special exhibit to the Meteorological Section in the Science Court of the Franco-British Exhibition, the most important part of which was a series of books and papers illustrating the history and literature of Meteorology. The Society has been awarded a Diploma of the Grand Prize for its Exhibit in Classes 1-6, and in Class 15.

Lectures.—Mr. W. Marriott, the Society's Lecturer, under its scheme of diffusing a knowledge of Meteorology, has delivered lectures at Charterhouse School; Reading School; Royal Agricultural Society's Show, Newcastle-on-Tyne; Shu-le-crow, Keswick; St. Lawrence College, Ramsgate; Christ's Hospital; Literary and Scientific Society, Wolverhampton; Uppingham School; Harrow School; and Natural History and Philosophical Society, Tunbridge Wells.

Proposed Meteorological Conference.—In February a letter was received from the Royal Society of Canada inviting the Society to send a delegate to a proposed meeting of Imperial and Colonial Meteorologists to be held at Ottawa in May 1908. In the month of March the Council were informed that the date of the proposed Conference had been altered to July 20 at Quebec. As this postponement made it possible for the President to attend, the Council requested him to be the Society's delegate. He consented to represent the Society at Quebec and took his passage to sail on July 10, but on June 27 a telegram was received postponing the Conference.

For Continuation of Report of the Council, see page 102.

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APPENDIX

STATEMENT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

Balance from 1907				£499	13 3
Subscriptions for 1908	£906	2	0		
Do. for former years	44	0	0		
Do. paid in advance	44	0	0		
Life Compositions	103	0	0		
Entrance Fees	72	0	0		
				1169	2 0
Meteorological Office—Returns 1907				99	0 11
Dividends on Stock (including £47 : 19 : 10 from the New Premises Fund)	£153	16	9		
Interest on Deposit, 1907 and 1908	12	7	1		
				166	3 10
Sale of Publications, &c.				78	16 2
Advertisements				22	10 0
				£2030	6 2

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I.

FOR THE YEAR ENDING DECEMBER 31, 1908.

EXPENDITURE.

Journal, &c.—		
Quarterly Journal, Nos. 145 to 148	£174 12 0	
Illustrations	24 13 6	
Authors' Copies	18 11 0	
Meteorological Record, Nos. 105 to 108	88 5 6	
		£306 2 0
Printing, &c.—		
General Printing	£20 8 10	
List of Fellows and By-laws	25 17 0	
Stationery	16 16 1	
Books and Bookbinding	23 8 7	
		86 10 6
Office Expenses—		
Salaries	£658 1 10	
Rent	212 0 0	
Coals, Lighting, and Insurance	18 9 2	
Addressograph, Furniture, and Repairs	23 6 4	
Postage	75 14 8	
Petty Expenses	9 14 1	
Refreshments at Meetings	15 2 1	
Telephone	6 10 0	
Lecture	10 10 0	
Expenses *re* German Meteorological Society's Anniversary	5 5 0	
		1034 13 2
Observations—		
Inspection of Stations	£47 15 11	
Observers	12 14 0	
Instruments	1 2 4	
		61 12 3
Stock—		
Purchase of £100 L. & N. W. Railway 4 per cent Preference Stock at 107	£106 16 8	
Purchase of £300 Victoria 3½ per cent Loan 1921-6 at 99	297 1 0	
		403 17 8
		£1892 15 7
Balance—		
At Bank of England	£128 19 2	
In hands of the Assistant-Secretary	8 11 5	
		137 10 7
		£2030 6 2

Examined, vouchers seen, and found correct,

T. P. NEWMAN,
J. W. FORRESTER, } *Auditors.*

January 12, 1909.

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APPENDIX

ASSETS AND LIABILITIES

LIABILITIES.

Subscriptions paid in advance	£44 0 0	
Rent for quarter ending December 25, 1908	53 0 0	
Coals and Electric Light	4 9 6	
Meteorological Record, No. 109, and General Printing	18 4 6	
		£119 14 0
Excess of Assets over Liabilities		3784 17 4
		£3904 11 4

WM. MARRIOTT, *Assistant-Secretary.*

NEW PREMISES FUND,

Interest received on Investment	£47 19 10

RESEARCH FUND,

Balance from 1907	£1 15 6
Interest received on Investment	1 16 0
	£3 11 6

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I.—continued.

ON DECEMBER 31, 1908.

ASSETS.

Great Central Railway 4½ per cent Debenture Stock, £800 at 120 xd.	£960	0	0			
New South Wales 4 per cent Inscribed Stock, £800 at 107 xd.	856	0	0			
Victoria 3½ per cent Loan, 1921-6, £300 at 98⅞ xd.	296	12	6			
London & North-Western Railway Consolidated Stock, £400 at 133	532	0	0			
London & North-Western Railway 4 per cent Preference Stock, £112 at 113	126	11	2			
Annuities, 2½ per cent, £231 : 11 : 9 at 82½ xd.	191	1	2			
				£2962	4	10
Subscriptions unpaid, estimated at	£50	0	0			
Entrance Fees unpaid	14	0	0			
Interest due on Stock	62	13	2			
Meteorological Office—Returns, 1908	89	12	6			
Do. Grant for Inspection, 1908	25	0	0			
				241	5	8
Furniture, Fittings, &c.	£454	8	10			
Instruments	109	6	5			
				563	10	3
Cash at Bank of England	£128	19	2			
Cash in hands of the Assistant-Secretary	8	11	5			
				137	10	7
				£3904	11	4

Examined, Securities seen at the Bank of England, and found correct,

January 12, 1909.

T. P. NEWMAN,
J. W. FORRESTER, } *Auditors.*

DECEMBER 31, 1908.

Amount paid to the Society's Fund towards the rent of Offices at 70 Victoria Street	£47	19	10

Note.—The Society holds on account of this Fund £1443 : 7 : 9 South Australian 3½ per cent Inscribed Stock.

Examined and Securities seen,

January 12, 1909.

T. P. NEWMAN,
J. W. FORRESTER, } *Auditors.*

DECEMBER 31, 1908.

Cash at Bank of England, December 31, 1908	£3	11	6

Note.—The Society holds on account of the Fund £72 : 11 : 5 Consols.

Examined and found correct,

January 12, 1909.

T. P. NEWMAN,
J. W. FORRESTER, } *Auditors.*

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APPENDIX

SYMONS MEMORIAL MEDAL

Balance in hand from 1907	£50 2 11
Interest received on Investment	18 18 0
	£69 0 11

LOCAL SCIENTIFIC SOCIETIES'

Balance from 1907	£108 15 5
Lectures—Fees	29 8 0
Contribution—Mr. F. Druce	10 0 0
Interest on Deposit, 1907 and 1908	4 12 1
	£152 15 6

KITE OBSERVATION

Balance in hand from 1907	£135 4 10
Grant from the Royal Society Government Grant Fund	100 0 0
	£235 4 10

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I.—continued.

FUND, DECEMBER 31, 1908.

Gold Medal		£25	0 0
Cash at Bank of England, December 31, 1908		44	0 11
		£69	0 11

Note.—The Society holds on account of this Fund £630 Cardiff Corporation Redeemable Stock, 3 per cent.

Examined and found correct,

January 12, 1909. T. P. NEWMAN, J. W. FORRESTER, } *Auditors.*

FUND, DECEMBER 31, 1908.

Lecturer's Fees		£17	15 0
Exhibit at Royal Agricultural Society's Show		35	9 0
Expenses *re* Franco-British Exhibition		4	0 2
Prizes for Teachers' Competition		13	10 0
Postage, Printing, etc.		1	13 7
		£72	7 9
Balance—At Bank of England		63	15 0
In hands of Assistant-Secretary		16	12 9
		£152	15 6

Examined and found correct,

January 12, 1909. T. P. NEWMAN, J. W. FORRESTER, } *Auditors.*

FUND, DECEMBER 31, 1908.

Balloon Observations at Birdhill		£46	16 5
Gasometer and Shed for Captive Balloon at Glossop		48	0 0
Meteorographs		5	0 0
Indiarubber Balloons		0	12 0
		£100	8 5
Cash at Bank of England, December 31, 1908		134	16 5
		£235	4 10

Examined and found correct,

January 12, 1909. T. P. NEWMAN, J. W. FORRESTER, } *Auditors.*

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Delegations.—Lt.-Colonel H. Mellish attended as the representative of the Society at the celebration of the fiftieth year of the foundation of the University Museum, Oxford, on October 8; and Mr. H. Harries, at the request of the President, acted as the representative of the Society at the twenty-fifth anniversary of the German Meteorological Society at Hamburg in September.

Meetings.—The evening Meetings of the Society took place, as in former years, by the courtesy of the President and Council of the Institution of Civil Engineers, at their house in Great George Street, Westminster; and the afternoon Meetings in May and June were held at the Society's Rooms, 70 Victoria Street.

Dinner.—The second Annual Dinner of the Society was held at the Trocadero Restaurant on Tuesday, June 16, at which 53 gentlemen, including a number of distinguished guests, were present.

Publications.—In addition to the *Quarterly Journal*, and the *Meteorological Record*, which have been issued as usual, a new edition of the List of Fellows was published on May 1.

Stations.—Offers to observe at the following new stations have been accepted, viz. Aberdare, Reading, and Redruth. All the stations in the north and east districts were inspected by Mr. Marriott, and found to be on the whole in a satisfactory condition. Mr. Marriott's Report will be found in Appendix II. (p. 103).

Phenological Report.—This Report was prepared as usual by Mr. E. Mawley, and was read at the April Meeting. The Society owes its best thanks to Mr. Mawley for his labours in collecting and discussing the returns from 109 stations, and for keeping in communication with so large a body of observers during so many years.

Library and Bibliography.—The additions to the Library during the year were 318 volumes, 391 pamphlets, 14 charts, and 31 MS. (See Appendix V.) The revision of the Library Catalogue has been continued. Additional accommodation for the storage of pamphlets is needed before much further progress can be made. 1508 authors and 1965 subject cards have been dealt with. During the year 7590 cards have been prepared for the Society's Bibliography of Meteorological Literature, in continuation of the Symons Bibliography, which becomes more valuable year by year; and 369 authors cards and 681 subject cards of works bearing on Meteorology published in the British Isles have been made for the *International Catalogue of Scientific Literature*. The Council have to express their recognition of the courtesy of the Editor of the *Geographical Journal* for supplying advance proofs of the monthly bibliography prepared for that Journal.

The question of providing adequate space for the ever-increasing additions to the Library is becoming a difficult problem which the Council will have to consider.

Fellows.—The changes in the number of Fellows are given in the following table:—

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Fellows.	Annual.	Life.	Honorary.	Total.
1907, December 31	555	159	18	732
Since elected . . .	+70	+ 2	+2	+74
Since compounded .	− 2	+ 2	...	0
Transferred	− 1	...	+1	0
Reinstated	+ 1	...	...	+ 1
Deceased	−10	− 5	−4	−19
Retired	−23	...	...	−23
Removed from List .	−11	...	...	−11
Lapsed	− 9	...	...	− 9
1908, December 31	570	158	17	745

Deaths.—The Council regret to have to record the loss by death of four Honorary Members and fifteen Fellows.

Alfred Baldwin, M.P.	elected	Feb.	20, 1901.
William Morris Beaufort, F.R.A.S.	„	Apr.	18, 1877.
Charles John Bromhead	„	Dec.	19, 1888.
John Barff Charlesworth	„	Feb.	18, 1880.
Sir John Eliot, K.C.I.E., F.R.S.	„	Feb.	20, 1878.
Robert Lewis John Ellery, C.M.G., F.R.S. (Hon. Member)	„	Jan.	17, 1894.
Sir John Evans, K.C.B., F.R.S.	„	Nov.	15, 1876.
Marquis of Gallidoro	„	Apr.	16, 1890.
Arthur Spry Helps	„	Feb.	15, 1893.
T. Almond Hind	„	May	16, 1900.
Albert Lancaster (Hon. Member)	„	Mar.	21, 1900.
Sir George Thomas Livesey, M.Inst.C.E.	„	Jan.	16, 1889.
Eleuthère Elie Nicolas Mascart (Hon. Member)	„	Dec.	16, 1896.
Dr. Josef Maria Pernter (Hon. Member)	„	Jan.	17, 1906.
David Lester Richardson	„	Jan.	16, 1907.
Mrs. Enrequita Rylands	„	Jan.	19, 1898.
James Lidderdale Scott, F.R.A.S.	„	Feb.	19, 1902.
Lieut.-Gen. Sir Richard Strachey, G.C.S.I., F.R.S.	„	Jan.	20, 1875.
Rupert Swindells, M.Inst.C.E., F.R.G.S.	„	May	17, 1876.

APPENDIX II.

INSPECTION OF STATIONS, 1908.

I have inspected the stations in the northern and eastern part of the country, and have found them to be generally in a satisfactory condition. 128 thermometers have been tested, and in only a comparatively few had a change of zero taken place. One rain measuring-glass was found to be incorrect. At one station, where there was a suspicion that the maximum temperatures had been occasionally too high, I found that the observer, after setting the instru-

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ment, while placing the thermometer on the left-hand screw, had unconsciously lowered the right-hand end of the instrument before placing that on the right-hand screw, and so the mercury had a tendency to run up the tube. It is very desirable that observers should always see that the reading of the maximum thermometer corresponds with that of the dry-bulb when it is suspended in the screws after being set.

At one station I found that wire netting had been placed over the rain-gauge, as it had been supposed that children had interfered with the gauge some time previously. This is the first occasion on which I have found a gauge to be so protected. I, however, recommended that the wire netting should be removed, and that a notice be placed near the gauge requesting that it should not be touched.

At Scarborough the ball of the sunshine recorder had numerous scratches and markings on its surface. These had apparently been made by the ball being put on the wall or roof when it was taken off for reading the card during the daytime. It is desirable at those stations where it is necessary to take the ball off for measuring the sunshine during the day, that a wooden bowl with soft padding inside should be used to place the ball in when taken off, in order to avoid scratching the surface.

WM. MARRIOTT.

October 1908.

NOTES ON STATIONS.

APPLEBY, *July* 8.—The instruments were in good condition. I recommended that the maximum be mounted slightly on the slant in order to prevent any tendency of the mercury to run up the tube. I gave the observer instruction as to the management of the wet-bulb in frost, and also as to reading the thermometers to tenths of a degree.

BELPER, *August* 12.—The thermometers are at Field Head House, and are read by Miss Hunter. The rain-gauge is at Quarry Bank under Mr. Hunter's personal supervision. I recommended that the plants and shrubs near the rain-gauge be kept low, and also that a thicker conducting thread be used for the wet-bulb thermometer.

BLACKPOOL, *July* 15.—The thermometers were in good order. The Snowdon rain-gauge has a hot-water jacket for melting snow. The Halliwell self-recording rain-gauge was in good order. The hour of measurement for the rain is 9 a.m., but for the 6 p.m. and 9 p.m. observations the amount is read off from the Halliwell recorder. The earth thermometer was at the commencement of the year placed at the depth of 4 feet below the surface. The Fortin barometer was in good order. The instrument was sent to the makers the previous autumn to have the mercury in the cistern cleaned. The sunshine recorder and the pressure tube anemometer and anemoscope were all in good order. The direction and force of the wind are taken from the records and not by observation. The 6 p.m. observations are telephoned to the Conservative Club for transmission to the Meteorological Office.

BUXTON, *July* 18.—Since the last inspection the plot of ground on which the thermometers are placed has been enclosed by iron railings, and earth thermometers at 1 foot and 4 feet added. The rain-gauge is outside the enclosure. The muslin on the wet-bulb thermometer was baggy and not of the proper description. The grass minimum had some spirit up the tube. The inside of the thermometer screen required painting. The rain-gauge needed some soldering. The mercury in the cistern of the barometer is becom-

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ing rather dirty. A barograph is placed near the barometer. The Campbell-Stokes sunshine recorder (Universal pattern) is now used in place of the Jordan recorder. The glass ball was not in the centre of the frame, being too low. The trees to the west make an angle of 12°. I suggested that, if possible, an endeavour should be made to have these kept cut back. I found that the earth thermometers had been read at 9 p.m. and not at 9 a.m. They will for the future be read at 9 a.m.

CHEADLE, *August* 14.—The instruments have been removed from the lawn near the house to the kitchen garden, and the observations have been taken since April by the new gardener. I recommended that grass be laid down, and that the screen be painted. The rain-gauge was too near the thermometer screen. The grass minimum had a considerable amount of spirit up the tube. The barometer had been removed from the arcade, and was fixed in a corner on a north wall; it was not quite perpendicular. I recommended that it be placed inside the observer's house. I instructed the observer in the method of reading the barometer and the thermometers. The observations are now taken only once a day, viz. at 9 a.m.

CHESTER, *July* 17.—The instruments were in the same position as last year. The minimum had some spirit at the top of the tube. The mercury in the maximum had a tendency to slightly run up the tube. I suggested that the instrument be placed more on the incline. The muslin on the wet-bulb required changing.

GORTON, *September* 3.—The thermometers and rain-gauge are on a grass plot in the kitchen garden. A row of peas had been allowed to grow up near the rain-gauge. The sunshine recorder (Universal pattern) was in good order. Owing to the growth of trees the recorder has to be moved to another post during the winter months.

DERBY, *August* 13.—The thermometer screen required painting. As the trees on the north-west of the rain-gauge subtended a considerable angle, I recommended that the gauge be moved farther away. The observations are now taken by one of the curators, who also reads the various meters in the Infirmary.

ELY, *September* 1.—The minimum had got out of order the previous week by the column of spirit becoming broken. This I set right. The thermometer screen required strengthening and painting. The maximum sets very stiffly, and requires a good deal of shaking. I recommended that it be mounted more on the slant. The muslin on the wet-bulb required changing. On comparing the thermometers it was found that the wet-bulb had gone up 0°·1.

GRANGE-OVER-SANDS, *July* 13.—The Jordan sunshine recorder is mounted on a post with a very good exposure, except on the west, where a house has recently been built, which subtends an angle of 9°. The recorder was not in proper adjustment for time. This was subsequently set right.

HARROGATE, *July* 21.—The barometer board was not fastened to the wall at the bottom. I recommended that it be secured in order to keep the barometer always perpendicular. Two screens, each with a set of thermometers, are used—one for the 9 a.m. and the other for the 6 p.m. observations. Underneath one of the screens is a thermograph, and under the other is a hygrograph. The muslin on the wet-bulb was baggy, and the cotton very thick. The receptacle for the 9 a.m. wet thermometer was higher than the bulb, so the water had a tendency to siphon out. I recommended that it be placed somewhat lower. The grass minimum had some spirit up the tube. Two rain-gauges are read daily: the Snowdon at 9 a.m. and the M. O. at 6 p.m.

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The Campbell-Stokes sunshine recorder (Universal pattern) was about 15 minutes fast in time. I, however, did not shift the instrument, but told the observer what he would have to do if the M. O. instructed him to adjust it. The Jordan recorder (Twin pattern) is still in use. Lander's direction and pressure anemometer is in use, and the wind observations have been taken from it. At the time of my visit the anemometer was not showing any pressure although the force was 1 and at times 2. At the Reservoir there is a Negretti and Zambra self-recording rain-gauge, with a check Glaisher gauge. There is also a 6-feet square evaporation tank with Halliwell float gauge, and also a percolation gauge. This station is fitted with every convenience for the help and comfort of the observer, for a complete electric lighting and heating installation has been introduced to replace the oil lamps and stoves previously in use. An electric lamp is also fitted in the night thermometer screen, a movable hand electric lamp is used for reading the sunshine recorders, and an electric kettle is provided for the melting of snow, ice, etc.

HILLINGTON, *September* 1.—The Rev. H. Ffolkes was away from home at the time of my visit, but I found one of the railway porters who took the observations in Mr. Ffolkes' absence. He appeared to take the observations fairly well. I gave him instruction in the method of reading and setting the instruments. The grass minimum had some spirit up the tube. The muslin on the wet-bulb did not fit very well, and the cotton required changing. The thermometer screen needed strengthening and painting. I recommended that the grass round the terrestrial minimum should be cut short. The sunshine recorder was in good adjustment.

HODSOCK, *August* 17.—Everything at this station was in good order. The sunshine recorder was in good adjustment. A tree on the east cuts off a little of the morning sunshine. Since my last visit a Dines' ether thermograph has been obtained, and is working satisfactorily.

KESWICK, *July* 11.—This station was in good order. In Mr. Dawson's absence the observations are taken by the gardener. The barometer is of an unusual construction, a screw at the top of the instrument adjusting the ivory point to the level of the mercury in the cistern. I urged the gardener always to adjust this, and also to make the vernier top form a tangent to the mercury in the tube. The solar thermometers were broken the previous day by a board being blown down on them while I was giving an address to a number of school children.

LANCASTER, *July* 13.—Too much muslin was used for the wet-bulb. I recommended that the maximum be mounted slightly on the slant to prevent the mercury running up the tube. The ball of the Campbell-Stokes sunshine recorder (Universal pattern) had slipped down so that the trace was not running quite parallel with the card. The Glaisher rain-gauge required some soldering. The thermometer screen required repairing and painting. As it had been wilfully damaged the previous day, and also the other instruments interfered with, I recommended that greater precautions should be taken for their protection, and suggested that the enclosure containing the rain-gauges should be made larger, and the screen removed to it.

LINCOLN, *August* 20.—Owing to the death of Mr. C. J. Bromhead on July 13, the observations which had been carried on by him since 1888 came to an end. I spent several days in the endeavour to find some one willing to carry them on. I called upon a number of persons connected with the Cathedral, including the Dean, Canon Hutton, Mr. A. Johnston, verger, and Mr. J. C. Allan, clerk of works, with reference to a new site for the Stevenson screen and rain-gauge, and also for the taking of the readings of the electrical thermometer, which is

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fixed on the great tower of the Cathedral and read off by a galvanometer in one of the vestries. I also called upon the Rev. T. R. Morgan with reference to a site which I considered very suitable at St. Margaret's disused burial-ground. Unfortunately, however, through technical difficulties, the consideration of this site had subsequently to be abandoned. I also called upon Dr. Rees Jones, the Medical Officer of Health, who was not able to render me any assistance. Ultimately Mr. J. C. Allan agreed, if possible, to endeavour to carry out some of the observations.

LOWESTOFT, *September* 4.—The minimum had 1°·2 of spirit up the tube. As the thermometer was an old one, and had a piece of wood covering the end of the tube, the spirit could not be seen until the piece of wood was taken off. The station had recently been painted. The thermometer screen had, however, been painted stone colour instead of white. The insides of the funnels of the rain-gauges had also been painted. It is not desirable that the rims of the gauges should be painted. The direction and force of the wind are taken by the officials at the lighthouse close by. The sunshine recorder appeared to be in good adjustment. The trees on the south-east and west-north-west make angles of about 6°. Mr. Edwards was away on holiday at the time of my visit, but the observations were being taken by Mr. Cooper.

MACCLESFIELD, *August* 13.—There was no change at this station. The minimum had 1° of spirit up the tube. This had been there since the thermometer had been obtained, as the observer was afraid that he might damage the instrument,—the previous instrument having been broken when trying to get spirit down. The observations are taken about 8.30 a.m.

MALDEN, *September* 22.—This station is at Worcester Park. The thermometer screen required painting. The tube of the maximum thermometer needed adjusting in order to make the divisions on it agree with those on the porcelain scale. The bulb of the 1 ft. earth thermometer was only 10 ins. in the ground. I recommended that the chain be lengthened by 2 ins. The rain-gauge measuring-glass gave too high a value for the greater part of the scale.

MATLOCK, *August* 12.—The instruments are at the Rockside Hydro, and the observations are taken by Mr. Evans, the Inspector of Nuisances. I suggested a rearrangement of the thermometers in the screen, and also that the screen be painted, and that a wooden rack be placed on the grass for the observer to stand on. A wire-netting screen, 4 ft. square and about 18 ins. high, was placed round the rain-gauge. This was also covered over with wire-netting, which had been put there, because it had been found that the rain-gauge had been tampered with by children some time ago. I recommended that the wire-netting at the top be taken away, and that a notice be placed near the rain-gauge, requesting that it should not be touched. The Jordan sunshine recorder is mounted on the roof of the Hydro, and has a clear exposure.

NORWICH, *September* 2.—This station was in good order. A wire-guard was placed over the grass minimum thermometer. I suggested that it be removed, and that a different form of protection be used for the thermometer.

RAUNDS, *September* 15.—This station was in good order. I recommended that the grass minimum be moved more into the open, and placed on well-cut short grass. A Snowdon rain-gauge had recently been obtained, and placed near the Glaisher rain-gauge. An electrical recording Robinson anemometer is mounted on the top of one of the ventilators of the Wesleyan school. The instrument has been designed by Mr. Cottingham of Thrapston.

ROTHBURY, *June* 17.—The sunshine recorder was not in adjustment for time. There was no change in the thermometers. I recommended the observer

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to notice whether the index in the minimum was shaken down in strong winds. The rain-gauge required some slight repair.

ROUNTON, *July* 7.—Since the last inspection a new house has been built for the gardener on the eastern side of the estate, and the instruments have been removed to a railed off enclosure in a field adjoining. The thermometer screen required painting. The maximum thermometer is one of Phillip's pattern. The proportion of mercury forming the index is only 4°·5 in length. This seemed to be much too short, as the air-speck was liable to work out of the mercury. I suggested that it was desirable that another instrument should be obtained. I gave the observer instruction as to the management of the wet-bulb in frost, etc.

SCALEBY, *July* 9.—I recommended that a batten be fixed on the top of the screen before the next painting in order to make it water-tight. I directed that the water receptacle be placed nearer to the wet-bulb, in order to prevent the cotton becoming looped, and so acting as a siphon. I gave the observer instruction as to the management of the wet-bulb in frost, etc.

SCARBOROUGH, *July* 22.—The water receptacle was higher than the wet-bulb. I recommended that it be lowered, to prevent the water syphoning out. As the observer had to take out the maximum and minimum thermometers for reading I brought away the thermograph, and recommended that the dry, wet, maximum and minimum thermometers be mounted more nearly in the middle of the screen, so that they could be easily read. The sunshine recorder is mounted on the stone coping at the top of the Fire Station; the exposure is clear all round. The ball had numerous scratches and markings on its surface. These apparently had been made by the ball being put on the wall or roof when it has been taken off for reading the card for the 6 p.m. observations. I advised that a wooden bowl be obtained, and that the ball be placed in it when taken off, in order to prevent any further scratchings. The barometer was at Mr. Larkins' house. The observations are taken at 9 a.m., 5.30 p.m., and a little before 9 p.m. I recommended that a grass minimum thermometer be obtained. On comparing the thermometers it was found that the minimum had gone up 0°·3

SCARBOROUGH (MANOR ROAD RECREATION GROUND), *July* 22.—The muslin and cotton on the wet-bulb were very dirty. The bottoms of the posts of the screen were rotten and needed renewing, and the screen painting. I gave the observer instruction in the method of observing.

SEATHWAITE, *July* 10.—The thermometer screen required painting and strengthening. The muslin on the wet-bulb was much too thick. The upper part of the weekly rain-gauge required soldering, and also the bottom of the can of the monthly gauge. Mrs. Jackson said that she might probably leave the house in September. I saw Mr. W. Richardson, who expressed his willingness to take the observations if the house should not be let. He has a piece of ground on the other side of Jackson's garden, where the instruments might be placed if necessary, or they could be put in the field near Marshall's gauge. The exposure at the latter is very open and bleak.

SINGLETON, *July* 16.—This station is three miles east of Poulton and six miles from Blackpool. A Campbell-Stokes sunshine recorder was to be set up on a marble pedestal in an exposed situation. There was, however, no sunshine at the time of my visit, so I could not adjust it. There are some trees to the east, which make an angle of 10°. I suggested that these should be cut back so as to reduce the angle. A Glaisher rain-gauge is also at work; it is kept very brightly polished. Mr. Miller has also a barograph.

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SOUTHWOLD, *September* 3.—I called on the Town Clerk, and learned that the observations were being taken on behalf of the Corporation by Mr. J. A. Blower, who was very glad of some instruction. Both the minimum and grass minimum thermometers had spirit up the tube. The muslin and cotton on the wet-bulb required renewing. The lower rim of the funnel of the rain-gauge had come off, and needed resoldering. The Robinson anemometer was not in good working order. The evaporation tank was not being used. The barometer is placed in the Town Hall. The case required fixing at the bottom in order to keep the barometer quite perpendicular. I was informed that the Corporation had decided to discontinue the meteorological observations at the end of the month.

SPROWSTON, *September* 2.—At the request of Mr. Eustace Gurney, I went to Sprowston Hall, three miles north of Norwich, and selected a site for the Campbell-Stokes sunshine recorder (Universal pattern). He has also a barograph, a thermograph, and a dial rain-gauge. He will probably obtain a Stevenson screen with thermometers, and also a Snowdon rain-gauge.

STRELLEY, *August* 11.—The muslin on the wet-bulb was rather baggy. I recommended that it be kept tight round the bulb. A new Snowdon rain-gauge has been obtained since the last inspection. The sunshine recorder required adjusting for time. As the trees on the east cut off some of the morning sunshine, I suggested that the recorder be moved farther to the west and mounted on a stronger support.

USHAW, *June* 29.—The legs of the screen required strengthening to check vibration in windy weather, and the screen also needed painting. On comparing the thermometers it was found that the dry and wet had gone up 0°·2. The rain-gauge has a shallow funnel. The cylinder is fixed to a wooden pedestal which needed readjusting. I gave the observer information as to the management of the wet-bulb in frost, and as to the measurement of snow, etc.

WAKEFIELD, *July* 20.—I saw four of the warders who take the observations, and also Dr. French who makes up the record. Owing to the exigencies of the prison duties, the evening observations are taken a few minutes before 8 o'clock, instead of at 9 p.m. The barometer, however, is read at 9 p.m. As the mercury in the maximum had a tendency to run up the tube when shaken, I recommended that the thermometer be mounted more on the slant. The thermometer screen soon gets very dirty owing to the smoky atmosphere; I recommended that it be cleaned and painted. Dr. French takes the wind and cloud observations.

WOODFORD, *September* 15.—This station is at Woodford House three miles west-south-west of Thrapston, and six miles east of Kettering. The instruments are placed on the lawn in front of the house, about 4 ft. from a slight embankment. Mr. E. N. Plevins has a Stevenson screen with thermometers, a black-bulb maximum *in vacuo* (about 6 in. above ground) a Glaisher rain-gauge, a Campbell-Stokes sunshine recorder, and an electrical recording cup anemometer by Cottingham of Thrapston. I selected a site for the sunshine recorder in the adjoining field, where, if raised some 10 ft. above the ground, it would be practically out of the influence of trees.

WRYDE, *August* 31.—The mercury in the maximum was found to be at the top of the tube. This was due to the thermometer having been tilted downwards when being suspended. I explained to the observer how to properly read and set the thermometer. The upper part of the muslin on the wet-bulb was dry. I urged the observer to always see that the muslin and cotton were in good condition.

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APPENDIX III.

OBITUARY NOTICES.

ALFRED BALDWIN was the youngest son of George Pearce Baldwin, iron founder, of Stourport, and was born in June 1841. He sat in the House of Commons from 1892 as Member for the Bewdley Division of Worcestershire.

Mr. Baldwin was Chairman of the Great Western Railway. He was also Chairman of "Baldwin's" (Limited), iron and steel and galvanised and tin sheet manufacturers and colliery proprietors.

He died suddenly of heart failure on February 13, 1908.

He was elected a Fellow of this Society on February 20, 1901.

WILLIAM MORRIS BEAUFORT was the youngest son of Admiral Sir Francis Beaufort, K.C.B., F.R.S., who was Hydrographer of the Admiralty from 1829 to 1855. He was born in London on July 20, 1823, and educated at St. Paul's School, from whence he proceeded in 1840 to the old East India College, Haileybury. In 1842 he left for Calcutta, where he joined the Bengal Civil Service, in the judicial ranks of which he served till 1871, when he retired. He settled shortly afterwards in the rooms at 18 Piccadilly, where he died on December 13, 1908. When at home on leave in 1857 he joined the Bar, but he never practised.

He was a member of the Athenæum Club, and Fellow of several learned Societies, including the Astronomical, Geographical, Statistical, Zoological, and Anthropological. He was also a Fellow and for some time on the Council of the Huguenot Society, and since 1882 a Director of the French Hospital at Victoria Park, of which his great-grandfather, the Rev. Daniel de Beaufort, was a Director in 1736. For some years he was Secretary of the French School attached to the French Protestant Episcopal Church of the Savoy, in Shaftesbury Avenue, and until his health gave way less than two years ago, he was the Treasurer of that Church and of its Poor Fund, which supports about fifty pensioners, the descendants of the Huguenot refugees.

He was elected a Fellow of this Society on April 18, 1877, served on the Council from 1883 to 1890, and was Vice-President in 1885.

CHARLES JOHN BROMHEAD of the Close, Lincoln, was born in August 1840. Although suffering from total deafness almost from childhood, his life was full of varied interests, and he became a considerable linguist, understanding French, German, and Norwegian. About twenty-five years ago he became devoted to the science of Meteorology. From 1888 until his death he had charge of the Royal Meteorological Society's electrical thermometer on the tower of Lincoln Cathedral, and he continuously reported his observations with the greatest assiduity and accuracy.

But perhaps the most important work of his useful life was the devotion he showed to the interests of the deaf and dumb. He acted as Secretary to the Lincoln Diocesan Mission to the Deaf and Dumb from its inception, the success of which may be entirely attributed to his exertions in its cause. He was also a member of the Charitable and Provident Society for granting Pensions to the Aged Deaf. He was the

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means of obtaining the admission of many deaf and dumb children into suitable schools, and afterwards befriended them and spent much money in getting them taught trades by which they were enabled to earn their own living. His life was well described as "an admirably gallant and good one." He died July 13, 1908.

He was elected a Fellow of this Society on December 19, 1888.

SIR JOHN ELIOT was born at Lamesby, Durham, on May 25, 1839. He went up to Cambridge University about 1866, and took his degree in 1869. As a young man his health was not robust, and he was advised to avoid the climate of England, so he accepted an appointment in the Indian Government Service as Professor of Mathematics in the Roorkee Engineering College. This he held from 1869 to 1872. He was than transferred to the regular Indian Educational Service as Professor of Mathematics at the Muir Central College at Allahabad, an appointment which he held from 1872 to 1874. In 1874 he was appointed Professor of Physical Science at the Presidency College, Calcutta, and combined this with the post of Meteorological Reporter to the Government of Bengal. On the retirement of Mr. H. F. Blanford he was, in 1887, appointed Meteorological Reporter to the Government of India and Director-General of Indian Observatories, which post he held until he retired in January 1903.

As a meteorologist India owes him a large debt of gratitude. As Meteorological Reporter to the Government of Bengal, he largely extended the meteorological system, and introduced daily weather reports with charts based on telegraphic information. He also instituted a comprehensive and effective system of storm warnings for coast stations round the Bay of Bengal, and of flood warnings for inland stations.

Among the more prominent of Sir John Eliot's publications are numerous accounts of cyclones and severe cyclonic storms occurring within Indian Seas; also numerous meteorological discussions, contributed chiefly to the *Indian Meteorological Memoirs*, and to the *Journal* of the Asiatic Society of Bengal. His last work was *The Climatological Atlas of India*, published by the authority of the Government of India; while at the time of his death he was engaged in writing "A Handbook of Indian Meteorology" to accompany this, also to be published under the direction of the Government of India.

He was a member of the International Meteorological Committee since 1894. He was greatly interested in the relation of cosmical physics to meteorology, and was Secretary of the International Solar Commission.

Sir John Eliot was elected a Fellow of the Royal Society in 1895; he was created a C.I.E. in 1897, and was given his K.C.I.E. on his retirement in 1903. He died at Cavalaire, Var, France, on March 18, 1908.

He was elected a Fellow of this Society on February 20, 1878, and was a member of the Council in 1904.

ROBERT LEWIS JOHN ELLERY was born at Cranleigh in Surrey on July 14, 1827. In early life he studied medicine, but devoted much of his leisure to astronomy and meteorology. He first went to Australia in 1851, and superintended in 1853 the erection of a small observatory at Williamstown for the Government of Victoria, which was constituted a separate colony in that year, having previously formed a part of New

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South Wales. The new establishment was removed to a more suitable site at Melbourne in 1863, and Mr. Ellery continued to direct its operations until 1895. Eight volumes of astronomical and twenty-eight of meteorological observations appeared under his directorate, besides two valuable star-catalogues, which were published in 1874 and 1889. Besides his astronomical and meteorological work, Mr. Ellery was much occupied from 1857 to 1870 in the geodetic survey of the colony. He was elected a Fellow of the Royal Society in 1873. He was for twenty-three years the President of the Royal Society of Victoria. He organised, and for a time commanded, the Victorian Torpedo Corps, now called that of the Submarine Mining Engineers; in retiring from this in 1889 the rank of lieutenant-colonel was conferred upon him. On completing his sixty-eighth year, Mr. Ellery resigned the Directorship of the Observatory, but continued to reside in Melbourne, and held the post of Chairman of the Board of Visitors until his death, which occurred on January 14, 1908. He received the honour of C.M.G. in 1897.

He was elected an Honorary Member of this Society on January 17, 1894.

Sir John Evans was born on November 17, 1823, at Britwell Court, Burnham, Bucks, and was the son of the Rev. Dr. Arthur Benoni Evans, headmaster of the Grammar School at Market Bosworth. He obtained his education under his father at this school, and was entered for matriculation at Brasenose, but an early call to business changed his career. Some sixty years subsequently he was elected to an Honorary Fellowship of this college, which gave him much gratification. His mother was a Dickinson, and he commenced his business life with the well-known firm of John Dickinson and Co., paper manufacturers, of Nash Mills, Hemel Hempstead, with which firm he was connected all his life. At the residence adjoining to the works he lived for more than fifty years.

His first published work was on *The Coins of the Ancient Britons*, which appeared in 1864, a supplement being added in 1890. He joined the Numismatic Society in 1849, and became its honorary secretary in 1854, holding that office until 1874, when he was elected President, an office which he retained until his death.

Sir John studied geology from his youth, and early turned his attention to the relation of geological structures to water supply. He was one of the first geologists in this country to appreciate the far-reaching importance of the discovery of flint implements and its bearing on the prehistoric condition of man. In 1872 he published his monumental work on *The Ancient Stone Implements, Weapons, and Ornaments of Great Britain*, a second edition of which appeared in 1897. In 1881 he published *Ancient Bronze Implements, Weapons, and Ornaments*.

In 1874 he was elected President of the Geological Society, and in successive years he filled the same office in several of the chief English societies, viz. the Anthropological Institute in 1877, the Society of Antiquaries in 1885, the Institution of Chemical Industry in 1892, the British Association in 1897, and the Egypt Exploration Fund in 1899. He was a correspondent of the Institute of France, a Trustee of the British Museum, and Treasurer of the Royal Society from 1878 to 1898; also Chairman of the Lawes Agricultural Trust Committee.

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The honour of K.C.B. was conferred on him in 1892.

He died on May 31, 1908, in the 85th year of his age.

Sir John Eliot was elected a Fellow of this Society on November 15, 1876, and was a member of the Council in 1877.

ARTHUR SPRY HELPS was the son of Richard Helps, and was born at Gloucester in 1845. He was educated at Rugby. The rest of his life was spent as a solicitor in Gloucester, and was one of quiet, unostentatious devotion to duty.

He took a great interest in meteorology, and kept rainfall records for a number of years.

He died in a railway accident on September 12, 1908.

Mr. Helps was elected a Fellow of this Society on February 15, 1893.

ALBERT LANCASTER was born at Mons on May 24, 1849, and in 1866 entered upon service at the Royal Observatory, Brussels, under the distinguished Director Adolphe Quetelet. In 1898 he was appointed Director of the Meteorological Service, which post he held till his death on February 3, 1908.

M. Lancaster had a great aptitude for the discussion of figures, and made a special study of climatology. He contributed numerous papers on this subject to the *Annuaire* and to the *Annales* of the Observatory, and also to the *Bulletins* of the Belgian Royal Academy. In 1895 he prepared an elaborate rainfall map of Belgium, and in 1898 he compiled, in conjunction with M. E. Meuleman, a work on the climate of the Congo.

M. Lancaster took a large share in the founding of the fortnightly publication *Ciel et Terre*, which is a popular review of astronomy, meteorology, and physics of the globe. He continued to take the greatest possible interest in this periodical up to the time of his death.

In 1903 he became a member of the International Meteorological Committee.

He was elected an Honorary Member of this Society on March 21, 1900.

GEORGE T. LIVESEY was born at Islington on April 8, 1834, and was the eldest son of Thomas Livesey, Secretary of the South Metropolitan Gas Company. At the age of fourteen he himself entered the service of the company, of which he became chairman in 1883. His whole life was devoted to the business of gas-making. He introduced the system of co-partnership among the employees of the company, which has been a great success.

He received the honour of knighthood in 1903.

Sir G. Livesey was a member of the Labour Commission 1891-4, and served on the War Office Committee on the Employment of ex-Soldiers, 1908.

He died on October 4, 1908.

He was elected a Fellow of this Society on January 16, 1889.

ÉLEUTHÈRE ÉLIE NICOLAS MASCART was born at Quarouble, near Valenciennes, on February 20, 1837. He was a scholar of the École normale supérieure, and took his degree of doctor of Science in 1864. His first post was that of conservator of the collections in the École

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normale. Then he became Professor of Physics in the Lycée de Versailles, and subsequently at the Collège Chaptal. Mascart also acted as deputy for Prof. Regnault at the Collège de France during the later years of that great master; and in 1872 succeeded him as Professor of Physics. Devoted to experimental physics, and, like his master, possessed of a great capacity for the methodical and patient treatment of details, he early made his mark in the scientific study of meteorology. In May 1878 he was appointed Director of the Central Bureau of Meteorology in Paris, and he filled this post for nearly thirty years, retiring only in 1907. He succeeded in the face of numerous difficulties in gradually perfecting the equipment and organisation of the Bureau, and in establishing the systematic publication in France of weather-charts and weather forecasts.

In 1884 he was elected to the Academie des Sciences, of which he became an active member, being at various times vice-president, permanent secretary, and in 1904, president. Being a man of affairs, he was frequently in request to advise the Government on matters within his competence. He was Vice-president of the Consultative Committee on Arts and Manufactures, and President on the Commission of Inventions for the War Ministry. He was also a member of the Bureau of Longitudes, and of the International Bureau of Weights and Measures. In recognition of his public services he was created Grand Officer of the Legion of Honour. He took a prominent part in organising the sections of the Exhibitions of 1889 and 1900, and in the latter year was President of the Electrical Congress which met in the Exhibition. He was a member of the Chicago Congress in 1893, after which he paid a visit to the Yellowstone Park. He was President of the Société française de Physique, and at another time of the Société internationale des Électriciens.

Mons. Mascart was elected in 1885 an Honorary Member of the Physical Society of London; in 1892 Foreign Member of the Royal Society; in 1900 Vice-President, and in 1901 Honorary Member of the Institution of Electrical Engineers.

Prof. Mascart was appointed a member of the International Meteorological Committee in 1878, and was President from 1896 until 1907.

He died at Poissy on August 26, 1908.

He was elected an Honorary Member of this Society on December 16, 1896.

Josef Maria Pernter was born on March 15, 1848, at Neumarkt, Tyrol. He entered the novitiate of the Society of Jesus in 1864, and became Professor of Physics at several colleges. He left the Society in 1877, and joined the Central Meteorological Institute of Vienna in 1880, and was appointed assistant in 1884. He obtained his degree of Doctor of Philosophy in 1882. He was made Professor of Cosmical Physics at Innsbruck University in 1890; and on the retirement of Dr. J. Hann in 1897 he was appointed Professor of Meteorology and Geodynamics at the University, and Director of the Central Meteorological Institute at Vienna.

Dr. Pernter wrote many valuable papers on various meteorological subjects which were printed in the publications of the Vienna Academy or the *Meteorologische Zeitschrift*. He also published an elaborate work on *Meteorological Optics*.

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Dr. Pernter was appointed a member of the International Meteorological Committee in 1898, and he was President of the Conference of Directors of Meteorological Institutes and Observatories, which was held at Innsbruck in 1905.

He died after a long illness at Arco, South Tyrol, on December 20, 1908.

He was elected an Honorary Member of this Society on January 17, 1906.

MRS. ENRIQUETA RYLANDS was the daughter of Mr. Stephen Tennant, and was born in Havana. In 1875 she married Mr. John Rylands of Longford Hall, Lancashire, the great Manchester merchant. Before her marriage to Mr. Rylands she had acted as his secretary. At his death in 1888 she succeeded to his great wealth, of which throughout the remainder of her life she spent large sums in works of public usefulness and philanthropy.

The John Rylands Library in Deansgate, Manchester, was erected to her husband's memory without regard to cost. It has been described as one of the most beautiful buildings in Europe, and at the opening ceremony, in October 1899, Principal Fairbairn of Mansfield College, Oxford, who delivered the inaugural address, spoke of it as "the most marvellous thing in history as a tribute of a wife's admiration of her husband and her devotion to his memory." The work of building had been in progress about two years when Mrs. Rylands purchased the Althorp Library, for which, it is understood, Lord Spencer had refused a tempting American offer. This library of 40,000 books, including Bibles in 300 languages and a fine collection of early printed works, is the nucleus of a rare collection now numbering at least 100,000 volumes, for Mrs. Rylands was never tired of adding to the treasures of the collection. In recognition of her gifts to the city the Manchester Corporation conferred the honorary freedom on Mrs. Rylands, and she received the degree of Litt.D. from Victoria University. Among her numerous benefactions was one of £25,000 to the forward movement of the Congregational Church. All her gifts were made in the most secret manner possible, and though her name appeared for large sums in all Manchester subscription lists, the extent of her benefactions will never be known.

Mrs. Rylands died at Torquay on February 4, 1908. She was elected a Fellow of this Society on January 19, 1898.

JAMES LIDDERDALE SCOTT was the son of Andrew Scott, and was born in Edinburgh in 1848. At the age of twenty-one he joined a mercantile firm in Shanghai, and continued to live there until a few weeks before his death. At the age of forty, though a very busy man, he commenced the study of astronomy, and devoted such time as could be spared to the measurement of double stars. He made many valuable measures, which he sent to the British Astronomical Association and to the Royal Astronomical Society. Leaving China early in 1908, he succumbed to an illness, dying on board ship on April 16, at the age of sixty.

He was elected a Fellow of this Society on February 19, 1902.

SIR RICHARD STRACHEY was born at Sutton Court on July 24, 1817, and was the third son of Edward Strachey of the Bengal Civil Service.

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In 1834 he entered the Indian Military Academy at Addiscombe, and two years later he left it at the head of his class, with a commission in the Bombay Engineers. On reaching India he served for a short time at Poona, and in 1839 he was transferred to the Bengal Engineers. In the following year he was posted to the Jumna Canal, one of the first large irrigation works undertaken by the Indian Government. He was next transferred to Hurdwar as executive engineer of the Ganges Canal, which had been begun in 1842 by Sir Proby Cautley. This peaceful work was interrupted by the first Sikh War (1845-46), and Strachey was attached to Sir Harry Smith's division. At the battle of Aliwal (January 28, 1846) his horse was shot under him. He made the authoritative plan of the Sikh position before the decisive battle of Sobraon, and assisted in the construction of the bridge across the Sutlej, whereby the British troops entered the Sikh territory. He received his brevet majority for these services, and when peace was made returned to his work on the Ganges Canal. But frequent attacks of fever compelled him to go to the hill station of Naini Tal, a retirement which led to some interesting scientific work.

After a short period of irrigation work in Bundelkhund, Strachey became in 1856 Acting Secretary to Government in the Public Works Department. In the great convulsion of the Indian Mutiny in the following year all peaceful work was naturally in abeyance, and when Mr. (afterwards Sir) John Peter Grant was placed in charge of the provisional government of the Central Provinces, with headquarters at Allahabad, he chose Strachey as his Secretary in all departments of Government.

Subsequently Lord Canning himself came to Allahabad, and Grant went to Calcutta to take up another post. Strachey, however, still remained at Allahabad, and was occupied in the restoration of that city, which had suffered much in the Mutiny. His ability was by now universally recognised in India, and he acted for a time in Lord Canning's Government as Secretary of Public Works, on behalf of Sir Henry Yule, although his actual official title was Consulting Engineer for Railways.

On Strachey's leaving India in 1871, Lord Mayo's Government took the unusual course of thanking him for his valuable services, and on his return to England he was appointed Inspector of Railway Stores at the Indian Office. In 1875 he was nominated by Lord Salisbury to the Indian Council, and in 1876 he retired from the army with the rank of Lieutenant-General.

Although he had retired from permanent office in India he returned there in 1877 on a mission connected with the purchase of the East Indian Railway by the Government, and remained until 1879, having been appointed President of the Famine Commission, and subsequently temporary Finance Minister in place of his brother Sir John Strachey.

In 1889 Lieut.-General Strachey resigned his life-tenure of membership of the Indian Council, to which he had been appointed by Lord Cranbrook, in order to take up the Chairmanship of the East Indian Railway Company. Under his leadership the mileage of the East Indian Railway rose from 1600 to 2700 miles, and it became one of the most prosperous railways in the world. He was also Chairman of the Assam-Bengal Railway; and he only resigned these positions in 1907, when nearly ninety years of age.

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Sir Richard was elected a Fellow of the Royal Society in 1854. In 1873 he became a member of the Meteorological Council, and was appointed Chairman in 1883, a post he continued to hold until the Council ceased to exist in 1905. In 1884 he represented Great Britain at the Prime Meridian Conference at Washington. He was President of the Royal Geographical Society during 1888-90.

He was the author of several works on geography, and also on geology and botany, as well as numerous papers on meteorological subjects.

He was awarded the Symons Gold Medal of the Royal Meteorological Society in 1906.

In 1866 he was made a Companion of the Star of India, and in 1897 he was advanced to the highest grade of the Order, the Grand Commandership.

He died on February 12, 1908.

Sir Richard Strachey was elected a Fellow of this Society on January 20, 1875, and his portrait appears in vol. 32 of the *Quarterly Journal*.

APPENDIX IV.

PURCHASES DURING THE YEAR 1908.

Books.

Cartes Synoptiques Journalières du Temps embrassant le Nord de l'Atlantique et une partie des continents avoisinants. December 1900 to November 1901.

Harrington, M. W.—About the Weather. Appleton's Home Reading Books, 8vo. New York, 1907.

International Catalogue of Scientific Literature.—Fifth Annual Issue, F. Meteorology.

New York, State Education Department. — Handbook 26. Secondary Education. Directions for performing the Laboratory Exercises contained in the syllabus for Physical Geography, September 1906. 8vo. (New York, 1906.)

On the Weather. Excerpt from the *Saturday Magazine*, August, October, and December, 1836.

Pernter, J. M.—Meteorologische Optik, Abt. 1-2. 8vo. Wien und Leipzig, 1902.

APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1908.

1. Books and Pamphlets.

Presented by Societies, Institutions, etc.

Aachen, Meteorologisches Observatorium.—Deutsches meteorologisches Jahrbuch, Aachen, 1906.

Adelaide, Observatory.—Meteorological Observations made at the Adelaide Observatory and other places in South Australia and the Northern Territory, 1905.

Antwerp, Expédition Antarctique Belge.—Resultats du Voyage du S. Y. *Belgica* en 1897-1899. Rapports scientifiques, Géologie, Océanographie et Physique du Globe.

Baltimore, Maryland Weather Service.—Volume II.

Bangalore, Central Observatory.—Mysore Meteorological Memoirs, No. 2.—Report on the Rainfall Registration in Mysore, 1907.

Barbados, Colonial Secretary's Office.—Returns of Rainfall in Barbados, 1908.

Batavia, Magnetical and Meteorological Observatory. — Observations, 1905.—Rainfall in the East Indian Archipelago, 1906.

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BERLIN, DEUTSCHE METEOROLOGISCHE GESELLSCHAFT.—Meteorologische Zeitschrift, Dec. 1907 to Nov. 1908.

BERLIN, GESELLSCHAFT FÜR ERDKUNDE.—Zeitschrift, 1907, No. 10, to 1908, No. 9.

BERLIN, KÖNIGLICH-PREUSSISCHES METEOROLOGISCHES INSTITUT.—Bericht über die Tätigkeit, 1907.—Bericht über die Versammlung des Internationalen Meteorologischen Komitees, Paris, 1907.—Deutsches meteorologisches Jahrbuch, 1906-7, Preussen und benachbarte Staaten.—Ergebnisse der Beobachtungen an den Stationen II. und III. Ordnung, 1902.—Ergebnisse der magnetischen Beobachtungen in Potsdam, 1905.—Ergebnisse der meteorologischen Beobachtungen in Potsdam, 1904.—Ergebnisse der Niederschlags-Beobachtungen, 1905.

BIDSTON, LIVERPOOL OBSERVATORY.—Report of the Director, 1906.

BIRMINGHAM AND MIDLAND INSTITUTE.—Records of Meteorological Observations taken at the Observatory, Edgbaston, 1907.

BOGNOR, CLIMATOLOGICAL SOCIETY. Bognor Urban District. Annual Report of the Medical Officer of Health and the Report of the Climatological Society, 1907.

BOLOGNA, OSSERVATORIO DELLA R. UNIVERSITÀ.—Osservazioni Meteorologiche, 1906.

BORDEAUX, SOCIÉTÉ D'OCÉANOGRAPHIE DU GOLFE DE GASCOGNE.—Rapports présentés à l'Assemblée générale de Janvier, 1907, et Février, 1908.

BREMEN, METEOROLOGISCHE STATION.—Deutsches Meteorologisches Jahrbuch, 1907. Freie Hansestadt, Bremen.

BRISBANE, GOVERNMENT STATISTICIAN.—Vital statistics, 1906.

BRUSSELS, ACADÉMIE ROYALE DE BELGIQUE.—Annuaire, 1908.—Bulletin de la classe des sciences, 1907, No. 9, to 1908, No. 8.

BRUSSELS, OBSERVATOIRE ROYAL DE BELGIQUE.—Annuaire météorologique, 1908.—Annales Météorologiques, **20**, Fasc. 4.

BRUSSELS, SERVICE MÉTÉOROLOGIQUE DE BELGIQUE.—Nouvelles recherches sur la température climatologique, par J. Vincent.

BUCHAREST, INSTITUT MÉTÉOROLOGIQUE DE ROUMANIE.—Buletinul Lunar al Observatiunilor Meteorologice din România, 1906.

BUITENZORG, INSTITUT BOTANIQUE DE L'ÉTAT.—Observations météorologiques, 1907.

BURTON-ON-TRENT, NATURAL HISTORY SOCIETY.—Transactions, **5**, part 1.

CAIRO, SOCIÉTÉ KHÉDIVIALE DE GÉOGRAPHIE.—Bulletin, **7**, Nos. 1 and 2.

CAIRO, SURVEY DEPARTMENT, PUBLIC WORKS DEPARTMENT.—Diagram of the Nile Gauge Readings for the year 1908, compared with the mean curve of past years.—Meteorological Report, 1905 and 1906, parts 1 and 2.—Magnetic Observations made April to December 1907 at Helwan Observatory.

CALCUTTA, METEOROLOGICAL OFFICE.—A Brief History of the Cyclone at Calcutta and Vicinity, October 5, 1864.—Indian Daily Weather Charts, Dec. 1, 1907, to Nov. 30, 1908.—Indian Monthly Weather Review, Jan. 1907 to Apr. 1908.—Indian Meteorological Memoirs, **20**, parts 2 and 4.—Memorandum on the Meteorological conditions prevailing in the Indian Monsoon Region before the advance of the South-west Monsoon of 1908, with an estimate of the probable Distribution of the Monsoon Rainfall, 1908.—Memorandum on the Meteorological conditions prevailing in the Indian Monsoon Region during the first half of the South-west Monsoon Period of 1908 with anticipations regarding the Monsoon Rainfall during Aug. and Sept. 1908.—Memorandum on the Meteorology of India during October and November 1907.—Meteorological Atlas of the Indian Seas and the North Indian Ocean.—Rainfall of India, 1906.

CAMBRIDGE, MASS., ASTRONOMICAL OBSERVATORY OF HARVARD COLLEGE.—Peruvian Meteorology: Observations at the Arequipa Station, 1892-1895. Observations made at the Auxiliary Stations, 1892-1895.

CAPE TOWN, SOUTH AFRICAN PHILOSOPHICAL SOCIETY.—Transactions, **17**, part 2; **18**, parts 2-3.

CARADOC AND SEVERN VALLEY, FIELD CLUB.—Record of Bare Facts, 1906.

CARLSRUHE, CENTRAL BUREAU FÜR METEOROLOGIE IM GROSSHERZOGTHUM BADEN.—Anleitung für die Meteorologischen Stationen im Grossherzogthum Baden.—Jahrbuch, 1907.—Niederschlags-Beobachtungen der meteorologischen Stationen, 1907, part 2.

CHRISTIANIA, NORWEGISCHES METEOROLOGISCHES INSTITUT.—Jahrbuch, 1907.—Nedböriagttagelser i Norge, 1907.

COLORADO, COLLEGE OBSERVATORY.—Annual Meteorological Summary, 1907.

COPENHAGEN, DANSK METEOROLOGISK INSTITUT.—Bulletin météorologique du Nord, Nov. 1907 to Oct. 1908.—Nautisk-Meteorologisk Aarbog, 1907.—Meteorologisk Aarbog, 1905, part 2; 1907, part 1.

CORNWALL COUNTY COUNCIL, SANITARY COMMITTEE.—Monthly Report, Dec. 1907 to Nov. 1908.

CRACOW, K. K. STERNWARTE.—Meteorologische Beobachtungen, Nov. 1907 to Nov. 1908.

CROYDON, NATURAL HISTORY AND SCIENTIFIC SOCIETY.—Daily Rainfall in the

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Croydon District, Nov. 1907 to Oct. 1908.—Report of the Meteorological Sub-Committee, 1907.

DAVOS PLATZ, KURVEREIN.—Davoser Wetterkarte, Nov. 1907 to Nov. 1908.

DEHRA DUN, TRIGONOMETRICAL SURVEY OF INDIA.—Account of the operations, 18.

DRESDEN, KONIGL. SÄCHS. LANDES-WETTERWARTE.—Dekaden Monatsberichte, 1906-1907.—Deutsches Meteorologisches Jahrbuch 1903-1904. Königreich Sächsen.

DUBLIN, ROYAL IRISH ACADEMY.—Proceedings, 27, Nos. 4 to 9.

EDINBURGH, GENERAL REGISTER OFFICE.—Quarterly Returns of the Births, Marriages, and Deaths registered in Scotland, for the year ending Sept. 30, 1908.

EDINBURGH, HIGHLAND AND AGRICULTURAL SOCIETY OF SCOTLAND.—Transactions, 20, 1908.

EDINBURGH, ROYAL SCOTTISH GEOGRAPHICAL SOCIETY.—Scottish Geographical Magazine, 1908.

EDINBURGH, ROYAL SOCIETY.—Proceedings, 28, Nos. 1 to 9.—The Temperature of the Fresh-water Lochs of Scotland, with special reference to Loch Ness, by E. M. Wedderburn.

EDINBURGH, SCOTTISH METEOROLOGICAL SOCIETY.—Journal, Third Series, No. 25, 1907.

EDINBURGH, SCOTTISH OCEANOGRAPHICAL LABORATORY.—Scottish National Antarctic Expedition. Report on the Scientific Results of the Voyage of the S. Y. *Scotia*, 2, Physics.

FELSTED, SCHOOL SCIENTIFIC SOCIETY.—Report, 1907.

GENEVA, SOCIÉTÉ DE GÉOGRAPHIE.—Coup d'oeil sur la Société de Géographie de Genève depuis sa fondation en 1858.—Le Globe, 47.

GLASGOW, ROYAL PHILOSOPHICAL SOCIETY.—Proceedings, 1906-1907.

GREENWICH, ROYAL OBSERVATORY.—Magnetical and Meteorological Observations. 1906.—Report of the Astronomer-Royal to the Board of Visitors, June 8, 1908.

GRENADA, COLONIAL SECRETARY'S OFFICE.—Meteorological Observations taken at Richmond Hill, Grenada, April to Oct. 1908.

HAMBURG, DEUTSCHE SEEWARTE.—Annalen der Hydrographie und maritimen Meteorologie, 1908.—Aus dem Archiv, 1907, Nos. 1 to 3.—Deutsche überseeische meteorologische Beobachtungen, Heft 15-16.—Ergebnisse der meteorologischen Beobachtungen, 1906.—Jahresbericht, 1907.—Tabellarische Reiseberichte nach den meteorologischen Schiffstagebüchern, 1906-1907.—Wetterbericht, 1908.

HONG-KONG, OBSERVATORY.—Abstract of Meteorological Observations, Nov. 1907 to Oct. 1908.—China Coast Meteorological Register, 1907.—Meteorological Observations, 1907.

INDO-CHINE, OBSERVATOIRE CENTRAL MÉTÉOROLOGIQUE ET MAGNÉTIQUE.—Bulletin Mensuel des Observations, Jan. 1907.

INNSBRUCK, METEOROLOGISCHE OBSERVATORIUM.—Beobachtungen, 1903, 1904, 1905.

JAGNY, OBSERVATOIRE DE CHEVREUSE.—Météorologie.—Résumé des Observations, 1903-1907.

JAMAICA, GOVERNMENT METEOROLOGIST.—Weather Report, Sept. 1907 to Sept. 1908.

JERSEY, OBSERVATOIRE ST.-LOUIS.—Bulletin des observations magnétiques et météorologiques, 1907.

KANSAS CITY, INTERNATIONAL WEATHER BUREAU.—The Earth's Temperature for the years 1908, 1909, and 1910.

LAGOS, SURVEY DEPARTMENT.—Southern Nigeria, Meteorological Returns, Jan. to July, 1908.

LEON, OBSERVATORIO METEOROLÓGICO.—Boletin mensual, Dec. 1907 to Oct. 1908.

LINDENBERG, K. PREUSS. AERONAUTISCHEN OBSERVATORIUM.—Ergebnisse der Arbeiten im Jahre 1906.

LISBON, OBSERVATORIO DO INFANTE D. LUIZ.—Boletim Meteorologico, 1908.—Observações dos Postos Meteorologicos, Anno de 1892, 1893.

LISBON, SOCIEDADE DE GEOGRAPHIA.—Boletim, 26, No. 11 to 27, No. 8.—A Riqueza Petrolifera d'Angola.

LIVERPOOL, CORPORATION TRAMWAYS.—Annual Report of the Traffic Manager, 1907.

LIVERPOOL, INSTITUTE OF COMMERCIAL RESEARCH IN THE TROPICS.—Quarterly Journal, 3, No. 6.

LONDON, ADMIRALTY HYDROGRAPHIC DEPARTMENT.—List of Oceanic Depths received at the Admiralty during the year 1907.

LONDON, AERONAUTICAL SOCIETY.—Aeronautical Journal, 1908.

LONDON, AIRSHIP NEWSPAPER CO.—The Airship and Aeronautical Engineer, 1, Nos. 1 and 2.

LONDON, ASSOCIATION OF WATER ENGINEERS.—Transactions, 12.

LONDON, BOARD OF AGRICULTURE AND FISHERIES.—Annual Report of Proceedings under Acts relating to Sea Fisheries, 1906.—Agricultural Statistics, 1907, Journal, 14, Nos. 10 to 15, No. 8.

Digitized by Google

LONDON, BRITISH ASSOCIATION.—Report, 1907.

LONDON, BRITISH BALNEOLOGICAL AND CLIMATOLOGICAL SOCIETY.—The Journal of Balneology and Climatology, 1908.

LONDON, GENERAL REGISTER OFFICE.—Quarterly Returns of Marriages, Births, and Deaths for the year ending Sept. 30, 1908.—Weekly Returns of Births and Deaths, 1908.

LONDON, GEOLOGICAL SOCIETY.—Quarterly Journal, 1908.—Geological Literature, 1908.—The History of the Geological Society of London, by H. B. Woodward.

LONDON, INDIA OFFICE.—Schlich's Manual of Forestry, 5, 2 ed.

LONDON, INSTITUTE OF SANITARY ENGINEERS.—Journal, 11, part 4 to 12, part 3.

LONDON, INSTITUTION OF CIVIL ENGINEERS.—Floods in Southern India, by J. M. Lacey.

LONDON, INSTITUTION OF ELECTRICAL ENGINEERS.—Journal, Nos. 187 to 192.—The Kelvin Lecture, by Prof. S. P. Thompson.

LONDON, METEOROLOGICAL OFFICE.—Daily Weather Reports, 1908.—Hourly Readings at the four Observatories in connexion with the Meteorological Office, 1907.—Instructions for Meteorological Telegraphy.—Memorandum on the Requirements of a Normal Climatological Station.—Meteorological Observations at Stations of the Second Order, 1903-4.—Meteorological Charts of the Southern Ocean between the Cape of Good Hope and New Zealand, 2nd edit.—Monthly Meteorological Charts of the Indian Ocean North of 15° S. Lat. and Red Sea, 1908.—Monthly Meteorological Charts of the North Atlantic and the Mediterranean, 1908.—Monthly Weather Report, Circular to Contributing Observers.—Observations at Stations of the Second Order and at Anemograph Stations, Jan. to Oct. 1908.—Report on the International Meteorological Conference at Innsbruck, September 1905.—Report of the Meteorological Committee for the year ending March 31, 1908.—Report on the Calculation of Wind Velocity from Pressure Distribution, and on the Variation of Meteorological Elements with Altitude, by E. Gold.—The Observer's Handbook.—Weekly Weather Reports, 1908.—Ceylon Administration Reports, 1907; Meteorology.—Administration Report of the Meteorologist, Calcutta, 1906-1907.—Annual Report of the Department of Agriculture of the Province of Alberta, 1905-6.—Brief Sketch of the Meteorology of the United Provinces and adjacent parts of Rajputana and the Punjab, 1906.

LONDON, METROPOLITAN WATER BOARD.—5th Report.

LONDON, PHYSICAL SOCIETY.—Proceedings, Nos. 124-125.

LONDON, ROYAL AGRICULTURAL SOCIETY.—Journal, 1907.

LONDON, ROYAL ASTRONOMICAL SOCIETY.—Monthly Notices, 1908.

LONDON, ROYAL BOTANIC SOCIETY.—Quarterly Record, Dec. 1907 to Sept. 1908.

LONDON, ROYAL GEOGRAPHICAL SOCIETY.—Geographical Journal, 1908.

LONDON, ROYAL INSTITUTION OF GREAT BRITAIN.—Proceedings, 18, part 3.

LONDON, ROYAL SANITARY INSTITUTE.—Journal, 28, No. 12, to 29, No. 11.

LONDON, ROYAL SOCIETY.—National Antarctic Expedition, 1901-1904. Meteorology, part 1: Physical Observations with Discussions by various Authors.—Proceedings, Nos. 536 to 549.

LONDON, ROYAL SOCIETY OF ARTS.—Journal, 1908.

LONDON, ROYAL STATISTICAL SOCIETY.—Quarterly Journal, Dec. 1907 to Sept. 1908.

LONDON, SOLAR PHYSICS COMMITTEE. — Monthly Mean Values of Barometric Pressure for 73 selected Stations over the Earth's Surface.—Report made to the Solar Physics Committee by Sir Norman Lockyer upon the work done in the Solar Physics Observatory, South Kensington, from January 1 to December 31, 1907.

MADRID, INSTITUTO CENTRAL METEOROLÓGICO.—Boletin, 1908.—Resumen de las Observaciones Meteorologicas, 1906-7.

MADRID, OBSERVATORIO.—Anuario, 1908.

MADRID, SOCIEDAD GEOGRÁPHICA.—Boletin, 49, No. 4, to 50, No. 3.—Revista de geografia colonial y mercantil publicada por la sección de geografia comercial, Actas de las sesiones celebradas por la sociedad por la junta directiva y por las secciones 4, No. 12 to 5, No. 10.

MANCHESTER, GODLEE OBSERVATORY.—Report, 1907.

MANCHESTER, LITERARY AND PHILOSOPHICAL SOCIETY.—Memoirs and Proceedings, 52, Nos. 1-3.

MANCHESTER UNIVERSITY, METEOROLOGICAL DEPARTMENT.—Report on the Investigation of the Upper Atmosphere carried out at the Howard Estate Observatory, Glossop, 1906-1907, and Jan. to Sept. 1908.

MANILA, PHILIPPINE WEATHER BUREAU.—Annual Report of the Director, 1905, part 2.—Bulletin, Feb. 1907 to Jan. 1908.—Curvas meteorograficas 1884, 1885, 1886, 1887, 1888.—Interesting Climatological data concerning the Weather of Manila.—La meteorologia en la Exposicion Colombina de Chicago (1893), por Pp. F. Faura y J. Algue.—Observaciones Magneticas en la Paragua, Jolo y Mindanao, 1888.—Observaciones verificadas, July to December 1879, July to December 1883, January to December 1884, January to December 1885, January to December 1887, February and October 1892, April and June 1893.—Typhoon-Warning Code of the Manila Observatory.

Digitized by Google

MARLBOROUGH COLLEGE, NATURAL HISTORY SOCIETY.—Report, 1907.

MARSEILLES, COMMISSION DE MÉTÉOROLOGIE DU DÉPARTEMENT DES BOUCHES-DU-RHÔNE.—Bulletin annuel, 1906-7.

MAURITIUS, ROYAL ALFRED OBSERVATORY.—Annual Report of the Director, 1907. —Results of Magnetical and Meteorological Observations, 1906.

MELBOURNE, COMMONWEALTH BUREAU OF METEOROLOGY.—A New Form of Pressure Anemometer.—Meteorological Observations made at the Perth Observatory and other places in Western Australia, 1906.—Rainfall Map of the Commonwealth of Australia.—The Climate and Meteorology of Australia.

MELBOURNE, MINISTER OF STATE FOR EXTERNAL AFFAIRS.—Papua, Annual Report for the year ending June 30, 1907.

MEXICO, OBSERVATORIO METEOROLÓGICO-MAGNÉTICO CENTRAL.—Boletin mensual, May to Dec. 1903, Jan. to Mar., and Oct. 1904, July 1907 to July 1908.—El Clima y régimen pluviométrico de la Ciudad de Leon, par M. Leal.—Tiempo probable durante el mes, Jan. to Mar., June, Oct., and Nov. 1908.

MEXICO, SOCIEDAD CIENTÍFICA "ANTONIO ALZATE."—Memorias y revista, **25**, Nos. 2 to 5; **26**, Nos. 1 to 3, and 6 to 9.

MILAN, R. OSSERVATORIO ASTRONOMICO DI BRERA.—Osservazioni meteorologiche, 1907.

MONCALIERI, OSSERVATORIO DEL REAL COLLEGIO CARLO ALBERTO.—Bollettino Meteorologico e Geodinamico, Dec. 1907 to Sept. 1908.

MORELIA, MEXICO, OBSERVATORIO METEOROLÓGICO.—Boletin Mensual de la Seccion Meteorológica del Estado de Michoacan, **1**, Nos. 1 to 5.

MOSCOW, SOCIÉTÉ IMPÉRIALE DES NATURALISTES.—Bulletin, 1907, Nos. 1 to 3.

NATAL OBSERVATORY.—Report of the Government Astronomer, 1907.

NEW YORK, CENTRAL PARK OBSERVATORY.—Abstracts of Registers from Self-recording Instruments, Nov. 1907 to Nov. 1908:

OÑA (SPAIN), COLEGIO MÁXIMO DE LA COMPAÑÍA DE JESUS.—Observaciones meteorológicas, 1907.

OTTAWA, DEPARTMENT OF THE INTERIOR.—Atlas of Canada.—Canada's Fertile Northland.

OTTAWA, DEPARTMENT OF MARINE AND FISHERIES.—Report of the Meteorological Service of Canada, 1905.

OTTAWA, DOMINION ASTRONOMICAL OBSERVATORY.—Report of the Chief Astronomer for the year ending June 30, 1906.

PARIS, BUREAU CENTRAL MÉTÉOROLOGIQUE DE FRANCE.—Annales, 1903, I., 1904, II., 1905, II., III.—Bulletin international, 1908.—Bulletin mensuel, Nov. 1907 to Oct. 1908.—Rapport de la conférence météorologique internationale. Réunion d'Innsbruck, 1905.

PARIS, OBSERVATOIRE MUNICIPAL.—Annales, tome **5-6**.

PARIS, SOCIÉTÉ MÉTÉOROLOGIQUE DE FRANCE.—Annuaire, Nov. 1907 to Oct. 1908.

PERPIGNAN, OBSERVATOIRE.—Bulletin météorologique annuel du Département des Pyrénées-Orientales, 1905.

PHILADELPHIA, AMERICAN CLIMATOLOGICAL ASSOCIATION.—Transactions, 1907.

PHILADELPHIA, AMERICAN PHILOSOPHICAL SOCIETY.—Proceedings, Nos. 187 to 189. Transactions, **21**, part 4.

POLA, K.-K. HYDROGRAPHISCHES AMT.—Erdmagnetische Reisebeobachtungen.—Jahrbuch der meteorologischen, erdmagnetischen und seismischen Beobachtungen, 1907.

PORT-AU-PRINCE, SOCIÉTÉ ASTRONOMIQUE ET MÉTÉOROLOGIQUE.—Bulletin annuel, 1907.—Résumés météorologiques, Oct. 1907 to Sept. 1908 (incomplete).

PRAGUE, K. K. STERNWARTE.—Meteorologische und magnetische Beobachtungen, 1907.

PRETORIA, TRANSVAAL METEOROLOGICAL DEPARTMENT.—Annual Report for the year ended June 30, 1907.

RIO DE JANEIRO, MINISTERIO DA MARINHA.—Boletim des observaçoes meteorologicas, Oct. 1906 to Mar. 1907.

RIO DE JANEIRO, OBSERVATORIO.—Annuario, 1908.—Boletim mensal, Jan. to June 1907.

ROME, SOCIETÀ SISMOLOGICA ITALIANA.—Bollettino, **12**, Nos. 6-11.

ROME, UFFICIO CENTRALE DI METEOROLOGICA E DI GEODINAMICA.—Annali, serie seconda, 1895, part 3.—Rivista meteorico-agraria, **28**, No. 30, to **29**, No. 31.

SABADELL, OBSERVATORIO.—Resúmen de las principales Observaciones verificadas en esta Estación Meteorológica durante el Quinquenio, 1902-1906.

ST. LUCIA, GOVERNMENT OFFICE.—Meteorological Statistics, Jan. to Oct. 1908.—Rainfall Returns, 1907.—Meteorological Returns, Botanic Station, 1907.

S. PAULO, COMISSÃO GEOGRAPHICA E GEOLOGICA.—Dados Climatologicos, 1898.

S. PAULO, DIRECTORIA DE AGRICULTURA. SECÇÃO METEOROLOGICA.—O Serviço Meteorologico e o Clima do Estado de S. Paulo. Serie 2. No. 3.

Digitized by Google

ST. PETERSBURG, OBSERVATOIRE MÉTÉOROLOGIQUE DE L'INSTITUT FORESTIER IMPÉRIAL.—Observations, 1906.

SALONIQUE, GYMNASE BULGARE DE GARÇONS "ST.-CYRILLE ET METHOD."—Bulletin annuaire, 1907.

SAN FERNANDO, INSTITUTO Y OBSERVATORIO DE MARINA.—Observaciones meteorológicas, magnéticas y sísmicas, 1907.

SARAJEVO, BOSNISCH-HERCEGOVINISCHEN LANDESREGIERUNG.—Ergebnisse der meteorologischen Beobachtungen, 1904-1905.

SIMLA, DIVISION OF THE CHIEF OF THE STAFF.—Weather in War time, by R. Bentley.

SIMLA, UNITED SERVICE INSTITUTION.—Journal, 33.

SOFIA, INSTITUT MÉTÉOROLOGIQUE DE BULGARIE.—Annuaire 1900, 1906, 1907.—Extrait du Bulletin météorologique, Jan. to Nov. 1908.

SOUTHPORT, FERNLEY OBSERVATORY.—Report and Results of Observations, 1907.

STOCKHOLM, K. SVENSKA VETENSKAPS AKADEMIE.—Arkiv für matematik, astronomi och fysik, 4, Nos. 1 to 4.

STOCKHOLM, METEOROLOGISKA CENTRAL-ANSTALT.—Månadsöfversigt af väderleken i Sverige, Dec. 1907 to Nov. 1908.—Meteorologiska Iakttagelser i Sverige, 1906-7.

STONYHURST, COLLEGE OBSERVATORY.—Results of Meteorological and Magnetical Observations, 1907.

STRASSBURG, INTERNATIONALE KOMMISSION FÜR WISSENSCHAFTLICHE LUFTSCHIFFAHRT.—Beobachtungen mit bemannten, unbemannten Ballons und Drachen sowie auf Berg- und Wolkenstationen, July 1906 to July 1907.

SYDNEY, ROYAL SOCIETY OF NEW SOUTH WALES.—Journal and Proceedings, 1903-1907.

TACUBAYA, OBSERVATORIO ASTRONÓMICO NACIONAL.—Anuario, 1908.

TEDDINGTON, NATIONAL PHYSICAL LABORATORY.—Report for 1907.—Report of the Observatory Department, 1907.

TOKIO, CENTRAL METEOROLOGICAL OBSERVATORY.—Annual Report, 1900, part 2; 1901, part 2; 1903, part 2; 1904, part 2.—Results of the Meteorological Observations made in Japan for each period of five years since 1876 and for the 10, 15, 20, 25, 30 years ending 1905.

TOKIO, METEOROLOGICAL SOCIETY OF JAPAN.—Journal, Nov. 1907 to Oct. 1908.

TORONTO, METEOROLOGICAL OFFICE.—Monthly Weather Review, Aug. 1907 to July 1908.

TRIESTE, I. R. OSSERVATORIO MARITTIMO.—Rapporto annuale, 1904.

TURIN, R. OSSERVATORIO ASTRONOMICO.—Osservazioni meteorologiche, 1906.

TURIN, SOCIETÀ METEOROLOGICA ITALIANIA.—Bollettino Bimensuale, 26, No. 8 to 27, No. 6.

UPSALA, OBSERVATOIRE MÉTÉOROLOGIQUE DE L'UNIVERSITÉ.—Bulletin Mensuel, 1907.

UTRECHT, K.-NEDERLANDSCH METEOROLOGISCH INSTITUUT.—Annuaire 1906.

VALPARAISO, SERVICIO METEOROLÓGICO, REPÚBLICA DE CHILI.—Anuario, 1906.

VICTORIA, DEPARTMENT OF AGRICULTURE.—Journal, 1908.—Report 1905-7.

VIENNA, K.-K. CENTRALANSTALT FÜR METEOROLOGIE UND ERDMAGNETISMUS.—Beobachtungen, Oct. 1907 to Nov. 1908.—Allgemeiner Bericht und Chronik der im Jahre 1905 in Österreich beobachteten Erdbeben, No. 2.—Jahrbuch, 1906.

VIENNA, K.-K. HYDROGRAPHISCHES ZENTRAL-BUREAU.—Jahrbuch, 1905.

WASHINGTON, CARNEGIE INSTITUTION.—Terrestrial Magnetism, 12, part 4, to 13, part 3.

WASHINGTON, HYDROGRAPHIC OFFICE.—Pilot Chart of the North Atlantic Ocean, 1908.—Pilot Chart of the North Pacific Ocean, 1908.

WASHINGTON, NATIONAL GEOGRAPHIC SOCIETY.—National Geographic Magazine, 1908.

WASHINGTON, SMITHSONIAN INSTITUTION.—Annals of the Astrophysical Observatory, 2, 1908.—Note on the Reflecting Power of Clouds, by G. C. Abbot and F. E. Fowle, Jr.—Excerpt Papers from the Smithsonian Report 1906, Nos. 1745-1748.

WASHINGTON, WEATHER BUREAU.—Bulletin of the Mount Weather Observatory, 1, parts 1-2.—Monthly Weather Review, Sept. 1907 to Sept. 1908.—Report of the Chief, 1905-6.—The Daily Normal Temperature and the Daily Normal Precipitation of the United States, by F. H. Bigelow.

WATFORD, HERTFORDSHIRE NATURAL HISTORY SOCIETY.—Transactions, 13, parts 3-4.

WELLINGTON COLLEGE, NATURAL SCIENCE SOCIETY.—Report, 1907.

WELLINGTON (N.Z.), REGISTRAR-GENERAL'S OFFICE.—Statistics of the Colony of New Zealand, 1906.—New Zealand Official Year Book, 1907.—Report on the Results of a Census of the Colony of New Zealand, taken for the night of the 29th April, 1906.

ZACATECAS, OBSERVATORIO ASTRONOMICO METEOROLÓGICO.—Boletin Mensual, Jan. to Nov. 1908.

Digitized by Google

ZAGREB (AGRAM), METEOROLOGISCHES OBSERVATORIUM.—Jahrbuch, 1903-1906, Theil. 3.

ZI-KA-WEI, OBSERVATOIRE MAGNÉTIQUE ET MÉTÉOROLOGIQUE.—Bulletin des observations, 1905.

ZOMBA, SCIENTIFIC DEPARTMENT.—Meteorological Observations, Sept. 1907 to Sept. 1908.

ZURICH, SCHWEIZERISCHEN METEOROLOGISCHEN CENTRAL-ANSTALT.—Annalen, 1906.

Presented by Individuals.

AKERBLOM, P.—Recherches sur les courants les plus bas de l'atmosphère au-dessus de Paris.

ARCTOWSKI, H.—De l'influence de la Lune sur la vitesse du vent aux sommets du Saentis, du Sonnblick et du Pike's Peak.—Notice sur les variations de longue durée des amplitudes moyennes de la marche diurne de la température en Russie.—Recherches sur la périodicité des phénomènes météorologiques à Bruxelles.—Variation des amplitudes des marches diurnes de la température au sommet du Pike's Peak.—Variations de longue durée de divers phénomènes atmosphériques.

BATES, Rev. D. C.—Rain-making Experiments at Oamaru.

BAUER, L. A.—Annual Report of the Director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, 1907.—The Relation between "Potential Temperature" and "Entropy."

BAXENDELL, J.—Meteorological Observations at Southport, Dec. 1907 to Nov. 1908.

BAYARD, F. C.—Annual Report, M.O.H. Surrey County Council, 1907.

BEMMENLEN, W. VAN.—On the Rainfall in Java.

BLADEN, W. W.—Annual Report North Staffordshire Field Club, 1907-8.

BODDAERT, D.—Misure magnetiche nei dintorni di Torino.

BRACKE, A.—La Revue Néphologique, 1908.

BROMHEAD, C. J. (the late).—Instructions in the Use of Meteorological Instruments (2nd edition).

BROWN, A., and BOOBBYER, (Dr.) P.—The Meteorology of Nottingham, 1907.

BUCHANAN, J. Y.—Ice and its Natural History.

CHEVALIER, H.—Federated Malay States, Pahang Administration Report for the year 1907.

CHREE, C.—Magnetic Declination at Kew Observatory, 1890 to 1900.

COLBORNE, H.—Annual Report, Meteorological Observations, Borough of Hastings, 1907.

COLLENETTE, A.—Fifth Annual Report of the Meteorological Observations taken at "Brooklyn," St. Martin's Road (Guernsey), 1907.

CONSTABLE & Co.—Airships Past and Present, by A. Hildebrandt.

COOK & SON, Messrs. T.—The Traveller's Gazette, Nov. and Dec. 1908.

CORBETT, (Dr.) D.—Report on the Health of the Borough of Kidderminster, 1907.

COTTON-JODRELL, Col.—Meteorological Observations taken at Roseneath Hall, Nantwich, 1907 (MS.).

COUTTS, (Dr.) F. J. H.—County Borough of Blackpool, Meteorology for the year 1907.

DALES, C.—Annual Meteorological Report for the County Borough of Bournemouth, 1907.

DAVIS, JOHN, & SON (DERBY), LTD.—Hygrometrical Tables.

DAWSON, A. M.—Rainfall recorded at Shu-le-Crow House, Keswick, 1907.

DIXON, C.—Results of Meteorological Observations taken at Holland House, Middlesex, Dec. 1907 to Nov. 1908 (MS.).

DIXON, F. J.—The Harlow Moor Observatory, Harrogate. Annual Report and Results of Observations, 1907.

DOVER, J.—Totland Bay: Report of Meteorological Observations, 1907.

DYMOND, T. S.—Suggestions on Rural Education.

EDITOR.—Ciel et Terre, 1908.

EDITOR.—Daily Graphic, 1908.

EDITOR.—Electrical Review, 1908.

EDITOR.—Indian Engineering, 1908.

EDITOR.—Journal of Horticulture, 1908.

EDITOR.—Knowledge, 1908.

EDITOR.—Nature, 1908.

EDITOR.—Observatory, 1908.

EDITOR.—Sanitary Record, 1908.

EDWARDS, C. W.—Annual Reports of the Medical Officer of Health, Borough and Port of Lowestoft, 1907.

EGINITIS, D.—The Climate of Greece. Part 1, Climate of Athens. Part 2, Climate of Attica.

Digitized by Google

EIFFEL, G.—Atlas météorologique pour l'année 1906 d'après vingt-deux stations françaises.—Atlas météorologique pour l'année 1907 d'après 24 stations françaises.—Comparaisons graphiques des valeurs mensuelles, saisonnières et annuelles des principaux éléments météorologiques dans diverses stations françaises pour l'année 1906.—Rapport sur un mémoire intitulé "Recherches expérimentales sur la résistance de l'air effectuées par M. G. Eiffel," par MM. Levy et Sebert.

EKHOLM, N.—Spannkraft des gesättigen Wasserdampfes und Eisdampfes.—Über das Psychrometer.

ENGELHORN, J.—Handbuch der Klimatologie, von Dr. Julius Hann, Band 1.

EREDIA, F.—I venti nello stretto di Messina.—Il regime pluviometrico sulle coste italiane.—L'umidità relativa dell' aria sulla Riviera Ligure.

FESSLER, A.—Das Klima von Innsbruck.

FOX, W. L.—Meteorological and Magnetical Tables and Reports, Falmouth Observatory, 1907.

FRASER, (Dr.) A. M.—Report on the Health of Portsmouth, 1907.

GAUTIER, R.—Observations météorologiques faites aux fortifications de Saint-Maurice, 1906.—Résumé météorologique pour Genève et le Grand St-Bernard, 1906.

GHEURY, M. E. J.—La variation diurne de la pression atmosphérique.

GIDDONS, H.—The Commonwealth Weather Chart, 1908.

GILCHRIST, D. A.—Summer Frosts and their effects on Swedes and Mangels in the North of England.

HANDS, A.—Protection from Lightning.

HANN, J.—Der tägliche Gang der Temperatur in der äusseren Tropenzone. B. Das Indische und Australische Tropengebiet.

HARVEY, Rev. C. W.—Observations of Temperature and Rainfall, Throcking, Buntingford, Herts, 1880-1904.

HEPWORTH, M. W. C.—A Comparison of the Changes in the Temperature of the Waters of the North Atlantic and in the Strength of the Trade Winds.

HEYWOOD, H.—Meteorological Observations in the [Cardiff] Society's District, 1907.

HILL, G. H., & SONS.—Returns of the Rainfall in the Glasgow, Manchester, Ashton, Dewsbury, Stockport, Halifax, Blackburn, Holme Reservoirs, Oldham, and Batley Waterworks Districts, 1907.

HJORT, Dr. J.—Some Results of the International Ocean Researches.

HOLMES, R. L.—Rainfall at Delanasua, Bua, Fiji, 1907.

HOPKINSON, J.—Climatological Observations taken in Hertfordshire, 1889.—Hertfordshire Earthquakes.—Meteorological Observations taken in Hertfordshire, 1897, and 1899.—Reports on the Rainfall in Hertfordshire, 1887, 1889, 1897, and 1900.—The Weather of 1905 and 1906 in Hertfordshire.

HUNTER, J.—Meteorological Observations at Belper, 1908.

IHNE, E.—Phaenologische Mitteilungen, 1907.

JAMESON, P. R.—Weather and Weather Instruments.

KING, SELL, and OLDING.—The Science Year Book, 1908.

KNOCHE, W.—Die äquivalente Temperatur, ein einheitlicher Ausdruck der klimatischen Faktoren "Lufttemperatur" und "Luftfeuchtigkeit."—Zur Wärmegehalt der Atmosphäre.

KOROSY, J.—Die Sterblichkeit der Haupt- und Residenzstadt Budapest in den Jahren 1901-1905 und deren Ursachen.

LAMB, E.—Climatological Observations taken at Borden Wood, Chithurst, Sussex, 1904-1907.

LEYST, E.—Beobachtungen angestellt im meteorologischen Observatorium der kaiserl. Universität Moskau, 1903, 1904.—Meteorologische Beobachtungen in Moskau, 1905, 1906.—Höfe um Sonne und Mond in Russland.—Luftelectrische Zerstreuung und Radioactivität in der Höhle Bin-Basch-Choba in der Krim.—Über das Erdbeben von San-Francisco nach den Aufzeichnungen der Seismographen in Moskau.—Über Schätzung der Bewölkungsgrade.

MANISSADJIAN, J. J.—Meteorological Records of Anatolia College, Merzifun, Asia Minor, 1907.

MARILAUN, F. KERNER v.—Untersuchungen über die Veränderlichkeit der jährlichen Niederschlagsperiode im Gebiete zwischen der Donau und nördlichen Adria.

MARKHAM, C. A.—Meteorological Report for Northamptonshire, Oct. 1907 to Oct. 1908.

MARSHALL, Miss C.—Rainfall in the Lake District, Dec. 1907 to Nov. 1908.

MAWLEY, E.—Meteorological Observations at Rosebank, Berkhamsted, Dec. 5, 1907, to Dec. 3, 1908.

MEINARDUS, W.—Die Lufthülle der Erde.—Skizze des Klimas der Heard-Insel.

MELLISH, H.—Some Air Temperature Readings at several Stations on sloping Ground, by R. S. Vinson and E. J. Russell.—The Weather of 1907 at Hodsock Priory, Worksop.

Digitized by Google

MIDGLEY, T.—Annual Report of the Museums and Meteorological Observatory, Bolton, 1907.

MILL, (Dr.) H. R.—British Rainfall, 1907.—Symons' Meteorological Magazine, 1908.

MOORE, Sir J. W.—Is our Climate changing?

MURRAY, J.—Climate considered especially in Relation to Man, by R. de C. Ward.

NEWCOMB, S.—A Search for Fluctuations in the Sun's Thermal Radiation through their Influence on Terrestrial Temperature.

PARNABY, J. M.—Meteorological Report for Albert Park, Middlesborough, Dec. 1907 to Nov. 1908 (MS.).

PLATANIA, G.—Le osservazioni del vento in mare e la scala di Beaufort.

PRESTON, A. W.—Meteorological Notes, 1907.

RIJCKEVORSEL, (Dr.) VAN.—Konstant auftretende secundäre Maxima und Minima in dem jährlichen Verlauf der meteorologischen Erscheinungen. Fünfte Abteilung.

ROBINSON, T.—Hoylake and West Kirby Urban District Council. Meteorological Report and Results of Observations, 1907.

RUSSELL, Mrs.—List of Scientific Papers, etc., by the late H. C. Russell.

RYVES, R. A.—The King's Highway.

SALLE, O.—Das Wetter, 1908.

SAXBY, A. C.—Meteorological Report, Cheltenham, 1908.

SCHAEBERLE, J. M.—An Explanation of the Cause of the Eastward Circulation of our Atmosphere. — Geological Climates. — On the Origin and Age of the Sedimentary Rocks.—The Earth as a Heat Radiating Planet.—The Infallibility of Newton's Law of Radiation at known Temperatures.

SCHREIBER, P.—Allgemeine Theorie der Wagemanometer.

SNELL, E. H.—City of Coventry, Annual Report on the Health of the City, 1907.

STILWELL, H.—Returns of Rainfall, etc., in Dorset in 1907.

STOKES, J.—Annual Report of the Meteorology of Margate, 1907.

SYMONS, (Dr.) W. H.—Annual Report to the Bath Urban Sanitary Authority by the Medical Officer of Health, 1907.

TEISSERENC DE BORT, L.—Nécessité d'étendre le réseau des stations d'ascensions internationales en limitant au besoin le nombre des ascensions.

VINCENT, J.—Atlas des nuages.

WALTER, A.—On the Influence of Forests on Rainfall and the probable Effect of "deboisement" on the Agriculture of Mauritius.

WARRY, (Dr.) J. K.—Report on the Sanitary Condition of the Hackney District, 1906.

WATT, A.—The Climate of the British Isles.

WATZOF, S.—Bulletin seismographique de l'Institut météorologique central de Bulgarie, No. 3.—Tremblements de terre en Bulgarie, 1907.

WHITAKER AND SONS.—The Holiday Whitaker.

WORTH, R. H.—Twenty-fifth Report (Third Series) of the Committee on the Climate of Devon.—Rainfall in Devon especially for the years 1896-1905.

YAMASHINA, PRINCE.—Ergebnisse der meteorologischen Beobachtungen auf dem Tsukubasan im Jahre 1903.

LANTERN SLIDES.

MAWLEY, E.—Phenological Observations, 1907 (14).

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PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 20, 1909.

Ordinary Meeting.

Dr. HUGH ROBERT MILL, President, in the Chair.

Lieut. WALTER DE MOUCHET BAYNHAM, R.N.R., Park Avenue, Dover;
JOHN KNIGHT, M.D., D.P.H., Scarborough;
Capt. PERCEVAL NORMAN LAYTON, 94 Jermyn Street, W.;
WILLIAM PHILIP JAMES LE BROCQ, M.A., Brecon;
ROWLAND EDGAR NICHOLAS, F.L.S., Bitterne Park, Southampton; and
WALTER SEDGWICK, 83 Victoria Street, S.W.,
were balloted for and elected Fellows of the Society.

January 20, 1909.

Annual General Meeting.

Dr. HUGH ROBERT MILL, President, in the Chair.

Mr. H. N. FFARINGTON and Mr. S. C. RUSSELL were appointed Scrutineers of the Ballot for the Council.

REPORT OF THE COUNCIL.

The PRESIDENT, Dr. HUGH ROBERT MILL, said that as the Report of Council was printed and in the hands of all the Fellows, it was not necessary to go through the form of reading it. He suggested that the Report should be taken as read, and moved from the Chair that it be adopted. The object of this Report was that the Council once a year should render an account of their stewardship. It was now the habit for particular pieces of work undertaken by the Council to be mentioned at the beginning of each meeting, and in this way the Fellows were kept familiar with what was being done. The Report had, unfortunately, to begin by deploring the loss of a number of valued members of the Society. There had been an exceptional mortality among the Honorary Members during the past year. They regretted to have to record the deaths of Mr. R. J. L. Ellery, formerly Government Astronomer at the Melbourne Observatory, Victoria; of M. A. Lancaster, Director of the Meteorological Department of the Royal Observatory at Brussels; of Prof. E. E. N. Mascart, Director of the French Meteorological Bureau; of Prof. J. M. Pernter, the head of the Austrian Meteorological Service; of Sir Richard Strachey, who was formerly the chairman of the Meteorological Council of this country, and a Symons Gold Medallist; and of Sir John Evans. The work of the Council had been greatly aided by a number of Committees. It was only when a Fellow was elected a member of Council that he realised the amount of work required of that body, and this work had been as usual conscientiously carried out last year. A large part of the work of the Society had always been in the direction of research, and the Report presented an account of the work done. The Kite Committee, co-operating with the British Association, had made considerable advances in the study of the upper atmosphere. During the past year a Prize Competition for Teachers had been held, and a large number of essays on the subject of the teaching of meteorology in schools had been received. The Society had also organised

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important exhibits representing meteorological work at various places. For that at the Franco-British Exhibition the highest award had been given by the authorities. Mr. Marriott had delivered a number of lectures to Scientific Societies and schools. There had also been two interesting delegations of the Society. Mr. Mellish had represented it at the celebration of the fiftieth year of the foundation of the University Museum, Oxford, while Mr. Harries had been present at the Twenty-fifth Anniversary of the German Meteorological Society at Hamburg. In the statement of the work done in the Library, they would notice that numerous valuable accessions had been made, but the accommodation was now nearly exhausted. As regards the gains and losses in membership, the total now reached nearly 750 Fellows, the losses incurred through deaths and resignations during the past year having detracted from what would otherwise have been a large increase in Fellowship. The last part of the Report dealt with a statement of receipts and expenditure, which was duly certified by Mr. Newman and Mr. Forrester as auditors, and would, he thought, be generally felt to be satisfactory. He had the pleasure of moving "That the Report of the Council be received and adopted, and that it be printed in the *Quarterly Journal*."

Mr. F. CAMPBELL BAYARD said that he had great pleasure in seconding the proposal. Referring to the Report, he did not think sufficient had been made of the great work done by the Local Scientific Societies' Committee. He thought that Mr. Druce's initiative had been a very great thing for the Society, and felt sure that he would be gratified by the success which had attended his idea. The question of what to do with the essays received for the Prize Competition would come before that Committee. He, himself, thought they might probably be worked up in the form of a book for use in elementary schools.

The Resolution was adopted. [The Report is printed on p. 93.]

ALTERATION OF BY-LAWS.

The PRESIDENT referred to the alteration in the By-Laws as stated in the Report of Council. He said that as a general rule the less the By-Laws of any Society were interfered with the better; but in order to bring them into harmony with what had become the usage of the Society, it had seemed right to the Council that an alteration in No. 4 should be made. A certain amount of change in the Council from year to year was felt to be very desirable. Hitherto the change might, without disobeying the By-Law, consist merely in transferring several members of Council to the Vice-presidentship, and *vice versa*; and it was felt to be better that this should not occur. The effect of the new proposal would be, that there should always be at least three Fellows as Members of Council who had not served on the Council in any capacity during the year immediately preceding. As regards By-Law 62, as matters stood, if any person presented a paper to the Society, which it was not thought proper to publish, the writer was prevented from making any use of the paper for the next twelve months. It seldom occurred that a paper of any importance was refused, but still it was thought expedient, in the interest of the Fellows, that the change should be made, and that it should be possible for an author to have the immediate right of dealing with his paper if it were declined. These slight changes did not affect the custom of the Society as followed in recent years.

The PRESIDENT proposed "That the following alterations be made in the By-Laws:—

(*a*) That By-Law 4 be altered to read as follows: 'At least three of the Council as defined in By-Law 2 shall be Fellows who have not served on the Council in any capacity during the year immediately preceding.'

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(*b*) That in By-Law 62 the word 'decline' be substituted for the words 'refuse or omit within a year.'"

Mr. H. MELLISH seconded the Resolution, which was adopted.

THANKS TO THE COUNCIL AND AUDITORS.

Mr. JOHN HOPKINSON moved "That the thanks of the Society be given to the Council for their services during the past year, and also to the Auditors." He said that they were all, he felt sure, grateful to the Council for the ability with which the affairs of the Society had been conducted. This was no light matter, for there was a great deal of work to be done. To the enterprise and judicious management of the Council was due the general progress and present satisfactory condition of the Society, and in a great measure the increasing interest taken in meteorology throughout the country. They were also much indebted to the auditors for their work, which required great care.

Mr. A. BREWIN, in seconding the Resolution, said that the Report spoke for itself and for what the Council had done. He could heartily endorse the President's words about the work required of the Council, and that work had been most carefully and ably carried out.

The Resolution was adopted.

Commander W. F. CABORNE on behalf of the Council thanked the Fellows present for the kind manner in which the Resolution had been proposed, seconded, and carried. While the Council were conscious that they always endeavoured to fulfil their duties well, they deeply appreciated the expressions of approbation.

INSTITUTION OF CIVIL ENGINEERS.

Dr. C. THEODORE WILLIAMS said that he had to propose a motion which was always a popular one, and that was "That the thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution." He thought the Institution had behaved splendidly to them. The Society could use the beautiful room, well heated and well warmed, free of cost. The Institution was in its way a sister Society, and the two Societies had some subjects upon which both worked together. The Institution of Civil Engineers was one of the most important bodies in this country. Unlike similar bodies in other countries they had no Government support, but carried on their work unaided, and often gave counsel of much value to the Government. They had a splendid Institution, a large number of excellent, hard-working Members, and were engaged in all sorts of enterprises, and doing their best to advance the interests and education of the country. If they looked around them at the portraits of the Presidents of the Institution, it was easy to see where a great deal of England's true glory lay.

Captain M. H. CLARKE said he had much pleasure in seconding Dr. Williams' very able mention of the generosity of the Institution, in allowing the Society the use of their hall, and for the courtesy shown to them by the Council of the Institution.

The PRESIDENT remarked that they would regret that the beautiful hall, in which it had been their privilege to meet, was about to be demolished in order to make room for the new Government Offices. However, a more magnificent building with a still finer hall was to arise. He trusted the Institution would construe their gratitude in the traditional sense and find a place for them in their new building.

The Resolution was adopted.

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HUGH ROBERT MILL, D.Sc., LL.D.

(*President of the Royal Meteorological Society*, 1907-8).

From a Photograph by Messrs. Thomson.

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PRESIDENT'S ADDRESS.

The PRESIDENT then delivered an Address on "SOME AIMS AND EFFORTS OF THE SOCIETY IN ITS RELATION TO THE PUBLIC AND TO METEOROLOGICAL SCIENCE" (p. 65).

Mr. F. DRUCE said that the pleasant duty had fallen to him of tendering their most hearty thanks to Dr. Mill for his services during the past year as President, and for his Address that evening. It would take far too much time were he to attempt to go through in detail the services Dr. Mill had rendered to the Society during his term of office, but he would briefly refer to one or two points. He thought they had all been struck by Dr. Mill's admirable lecture. It contained useful lessons for various classes of persons, meteorologists and others, including the man in the street and the careless public. They had all been charmed by the way in which Dr. Mill had presided over the Society's meetings; his conduct also of the many meetings of Council and Committees had been admirable. In the Annual Report there were a number of matters detailed showing the progress of the Society, but Dr. Mill, while pointing out these matters had, with characteristic modesty omitted to mention that he had been the guiding spirit of most of them. He had given evidence before a Committee appointed by the Board of Agriculture to consider agricultural education. The result was that the Committee were of opinion that prominence might be given to Meteorology in this connection. He had also attended a Treasury Committee in connection with the Meteorological Office grant, and had arranged to attend as the Society's Delegate the Conference of Imperial and Colonial Meteorologists at Ottawa, which was unfortunately postponed. It might be some satisfaction to Dr. Mill to know that his Presidency had left the Society very prosperous, especially in the matter of increasing fellowship, and the Society might think itself fortunate to have had as their President a man eminent in Science and capable in administration. He begged formally to move: "That the thanks of the Society be given to Dr. Hugh Robert Mill for his services as President, and for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal*."

Dr. W. N. SHAW seconded the vote of thanks.

The Resolution was adopted.

The PRESIDENT, in reply, said that he thanked them very much for agreeing with the too generous words of Mr. Druce and Dr. Shaw. He certainly was not so excessively modest as to wish to disguise the fact that he had done the best he could in the interests of the Society during his term of office. It had been a great pleasure to work with so agreeable a Council as that of the Society. He did not think—apart from the too flattering way in which Mr. Druce had spoken of the President's services—that he had exceeded the truth, when he spoke of the work of the Council; but he had suppressed something in passing over the immense help which he, Mr. Druce, had rendered in that work. He, the President, looked forward after quitting his office to continue to assist the Society, it might be with less expenditure of time, but not with less heartiness and goodwill. He thought the Society should strive to have 1000 Fellows before the end of his successor's term of office, and he hoped it would impress itself more and more upon the public as being the centre of scientific work and publications in Meteorology.

[A Portrait of Dr. H. R. MILL is given on Plate I.]

ELECTION OF COUNCIL.

The Scrutineers then declared the following to be the Council for the ensuing year:—

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PRESIDENT.

HENRY MELLISH, D.L. J.P., F.R.G.S.

VICE-PRESIDENTS.

WALTER WILLIAM BRYANT, B.A., F.R.A.S.
WILLIAM HENRY DINES, B.A., F.R.S.
COMMANDER MELVILLE WILLIS CAMPBELL HEPWORTH, C.B., F.R.A.S.
HUGH ROBERT MILL, D.Sc., LL.D., F.R.S.E., F.R.G.S.

TREASURER.

CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P., M.V.O.

SECRETARIES.

FRANCIS CAMPBELL BAYARD, LL.M.
COMMANDER WARREN FREDERICK CABORNE, C.B., F.R.G.S., F.R.A.S.

FOREIGN SECRETARY.

ROBERT HENRY SCOTT, M.A., D.Sc., F.R.S.

COUNCILLORS.

RICHARD BENTLEY, F.L.S., F.R.G.S.
FREDERICK JOHN BRODIE.
CHARLES JOHN PHILIP CAVE.
HENRY NEWTON DICKSON, M.A., D.Sc., F.R.S.E., F.R.G.S.
FRANCIS DRUCE, M.A., F.R.G.S.
ERNEST GOLD, M.A.
RICHARD INAWRDS, F.R.A.S.
BALDWIN LATHAM, M.Inst.C.E., F.G.S.
RUDOLF GUSTAV KARL LEMPFERT, M.A.
COLONEL HERBERT EDWARD RAWSON, R.E., C.B., F.R.G.S.
CAPT. ROBERT CAMPBELL WARDEN.
CAPT. DAVID WILSON-BARKER, F.R.S.E., F.R.G.S.

INSTALLATION OF NEW PRESIDENT AND SECRETARY.

The PRESIDENT said there was only one duty left him in his official capacity, and that was to give effect to their election of the late Honorary Secretary, Colonel Mellish, as President of the Society; and in asking Colonel Mellish to take the chair, he could assure him that he would find it a pleasant position, surrounded by the helpful Council which he knew so well. Colonel Mellish would make an ideal Chairman, as he was accustomed from his high position in the Territorial Army to a stricter form of discipline than their present—he should say their past — President could wield. Colonel Mellish was the Chairman of a very important Education Committee, and accustomed to dealing with public matters and public meetings. He, Dr. Mill, had always had a great dislike of formality, and he feared that the Society might have run some risk of deteriorating under his chairmanship, but Colonel Mellish would put that right, knowing, as he did, the work of the Society well and having the thorough confidence and regard of all the members of the Council. He had the great pleasure of presenting Colonel Mellish with the Presidential Key, the visible symbol of his office.

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Mr. H. MELLISH said he thanked them extremely for the great honour they had conferred upon him in electing him their President, and also thanked Dr. Mill for his kind expressions. He knew that in succeeding to the post occupied by so many distinguished Meteorologists, he would have the support and assistance of the members of the Council. He could not help regretting that they were losing the services of several who had served on the Council for a considerable time, but the alteration in the By-Laws had been made for the purpose of securing new members. There was a rather larger number of vacancies than usual, but he hoped that the absences might be only temporary. He welcomed the new members with pleasure; among them was their new Secretary, Commander Caborne, whom he would ask to take his seat on the platform.

Commander W. F. CABORNE thanked those present for the kind manner in which they had received his election. He hoped that when his period of office had expired they would be able to say that their confidence had not been misplaced.

February 17, 1909.

Ordinary Meeting.

HENRY MELLISH, F.R.G.S., President, in the Chair.

FREDERICK FEATHER, 3 Mount Pleasant, Chepstow;
FRANCIS HAROLD FRENCH, 43 Warwick Street, Worthing;
ROBERT HARPER, F.R.G.S., F.S.S., London; and
QUAH BENG KEE, Penang, Straits Settlements,
were balloted for and elected Fellows of the Society.

The PRESIDENT, before proceeding to the ordinary business, said it was his melancholy duty to refer to the recent death of Mr. HENRY STORKS EATON, who had been for some years the senior Fellow of the Society. He was elected in 1857, and filled the office of President in the years 1876-77. Mr. Eaton had always taken an active interest in the work of the Society, and had been a familiar figure at the Meetings until recent years. His death was much to be regretted, and the Society was distinctly poorer by his removal. He (the President) had been looking up Mr. Eaton's Presidential Addresses, and it was curious to note that in the first, Mr. Eaton referred to our small amount of knowledge of the conditions prevailing in the upper air. In those days there were very few balloons in existence, and special reference was made to the recent opening of a high-level Observatory, that of the Pûy-de Dome; the use of kites in meteorological research had not then been thought of. This Address was of great interest in view of recent investigations. In Mr. Eaton's second Address, he referred to the position of Hygrometry, and pointed out how unsatisfactory our knowledge was of the reading of the dry- and wet-bulb thermometers, and that the time spent in working up deductions from their readings might be better spent on the study of evaporation. He (the President) thought that we had not made much progress in that branch of Meteorology during the past thirty years, and this view was borne out in the discussion of the Antarctic Observations, taken during the voyage of the *Discovery*. In working up the Observations, it was found that the readings of the wet-bulb thermometer at very low temperatures were hardly worth taking any notice of owing to their uncertain meaning. He also referred to the approaching 70th birthday of Dr. Julius Hann, who was awarded the Symons Medal in 1904. The Council at their meeting that evening had decided to send an address of congratulation to Dr. Hann. The President concluded by remarking that at the next meeting of the

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Society, on March 17, they were to be favoured with a Lecture by Dr. Vaughan Cornish on "Wind Waves in Water, Sand, and Snow." This was a subject which Dr. Cornish had made entirely his own, and there was no doubt he would have much of interest to say to them. He hoped that there would be a large attendance to welcome Dr. Cornish.

The following Communications were read :—

1. "Report on the Phenological Observations for 1908." By Edward Mawley, F.R.H.S. [This Report will be printed in a later number of the *Quarterly Journal.*]

2. "The Cold Spell at the end of December 1908." By William Marriott, F.R.Met.Soc. (p. 81).

CORRESPONDENCE AND NOTES.

Proposal to Express all Measurements of Atmospheric Pressure by a Universal Measurement of Force.

In the U.S. *Monthly Weather Review* of November 1908, Prof. A. G. M'Adie, chief officer of the Weather Service at San Francisco, makes a very noteworthy proposal. He thinks the Weather Bureau should adopt as soon as practicable the centigrade and metric scales for the measurement of temperature, wind, rainfall, and snow, but should free itself from the consequences of the accidental circumstance that mercury is used in the construction of barometers, by adopting 1000 on an arbitrary scale of units as the equivalent of the normal pressure of 760 mm. = 29·92 ins.

The agreement of the meteorological world, with respect to measures and scales, by the change of English and Americans to metric measures and centigrade, as Prof. M'Adie proposes, would be a step in advance which is earnestly to be desired. One cannot expect such a widely extended system to alter its measures without first being convinced of the complete desirability and justification of the change. And it cannot be contested that our measure of atmospheric pressure does at present possess these qualities.

Prof. M'Adie's proposal to take 760 mm., which is now made use of as "one atmosphere," as the unit for all measurements of pressure would certainly be an unmistakable advance ; but this "normal pressure" is quite a conventional quantity. The mean pressure even at sea-level differs considerably in different places. The adopted value of 760 mm. is only connected with the metric system by a new quantity—the density of mercury. If one makes it independent of this it denotes a pressure of 1033·291 grams weight upon one square centimetre, when the gram is taken as the unit of force. But it is acknowledged by physicists generally to be more rational, not to consider the gram as the unit of force but as the unit of mass, and to take as unit of force its product, with the "normal" acceleration of gravity, in lat. 45°, at sea-level, 980·65 cm.[1] In the C.G.S. system a barometer reading of 760 mm. [29·92 ins.] at normal gravity corresponds therefore to 1,013,303 units. 1,000,000 of such units would therefore correspond to a mercurial pressure of

[1] For physical geography it might be convenient to take as unit the pressure of a column of water of one full metre—in other words, to put the acceleration of gravity at 45° not as 981, but as 1000 ; this would, however, depart from the purely C.G.S. system. In oceanographical investigations the Scandinavian physicists calculate with "dynamic metres" of about 1·02 m. in length. In that way they express in the same rational unit pressure, friction, and deviating-force of the earth's rotation.

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750·1 mm. [29·532 ins.]. This quantity can be taken as unit and might be called a *small atmosphere* or (with Bjerknes and Sandström [1]) a *Bar*. Then 1 *Decibar* is the pressure of a column of water 0·98 m. [38·6 ins.] in depth—distilled water at the temperature of maximum density and normal gravity presupposed, or 1 Megadyne per square centimetre.[2] The Millibar is nearly $\frac{3}{4}$ or more exactly 0·75006 mm. of mercury The abbreviations will, of course, correspond to the others of the metric system, viz. *b*, *db*, *cb*, *mb*.[3]

Starting from the prevalent assumption of a mean pressure of 760 mm. [29·92 ins.] at sea-level, we find the new pressure unit of 1000 mb. at a height of 106 m. [348 ft.] above the sea.

Whether this higher level will be made use of in the reduction to a normal level in meteorology, instead of sea-level, is a question independent of the introduction of this pressure scale. There is much to be said, however, in favour of this change. The mean altitude of the German stations in the *Wetterbericht* of the Seewarte is (apart from the mountain stations, for which the barometer readings are uncorrected for height), exactly 107 m. [351 ft.]; 17 of these stations are less than 100 m. [328 ft.] high, Frankfort-on-the-Main 103 m. [338 ft.]; and only 11 stations over 106 m. [348 ft.]. It would be the same, on an average, for Europe, and also in the eastern half of North America. Therefore for the majority of stations the new normal level would lie in the atmosphere, and the calculated pressure would have a real meaning, while at present the reduction-level for them lies in the ground, where the "air-pressure" denotes only a numerical value, and also the temperature used in the calculation has no reality. For the remaining stations the probable distortions made by this method are at least diminished. We may even regret that the level of the pressure unit has not come out somewhat higher, because the distribution of pressure a few hundred metres above the ground gives a much truer representation of the atmospheric circulation than that at the surface of the earth itself. The lower air masses are, even in low-lying places, in a great measure dragged along by the upper strata, *i.e.* they receive their impulse of motion mostly from air masses descending from some height, because on the ground friction or obstacles are too great.

The wish to reduce barometer readings generally to a somewhat higher level, instead of to sea-level, has often been expressed. It could not be carried out, because there was little prospect of agreeing to a perfectly arbitrary level. The level now proposed is no longer purely arbitrary, because it represents *the mean level of the unit of air-pressure* when 760 mm. [29·92 ins.] is taken as equal to the mean air-pressure at sea-level. As, however, the choice of this latter figure may vary between tolerably wide limits, we are free, for convenience in the determination of the distance from this level, to fix it somewhat differently, say at 100 m. in round numbers.

A chief motive of Prof. M'Adie's proposal is, however, regard for the general public. He points out for the establishment of his proposal that the public will be able much easier to form an idea about changes of air-pressure than at present, where the quantity 760 appears quite arbitrary. We may add, the more arbitrary, since as a "barometer" the public mostly only knows of the aneroid, and does not think at all about the mercury. "For example, the business man reads 1009, and knows without computation that the pressure is

[1] *Beiträge zur Physik der freien Atmosphäre* von Assmann und Hergesell, Bd. 2 S. 1, Strassburg, 1906. See also Sandström and Helland-Hansen in Report on Norweg. Fish. and Marine Invest. vol. ii. 1902, No. 4, S. 15, and Knudsen in *Bulletin trimestriel des Perman. Internat. Conseils für Meeresforschung*, 1906-7, No. 1, S. 41, No. 2, Taf. 14 ff.

[2] See Note 1 on previous page.

[3] In the "Beitrage" referred to in note 1, *mmbar* is printed by oversight for *mbar* or *mb*.

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nine points in a thousand above a normal pressure. At the present time, with the pressure expressed at 30·20 ins., even Weather-Bureau men must take pencil and paper to figure out the proportional change in pressure compared with a normal condition."

But it must not be forgotten that this only holds good for the barometer readings reduced to sea-level. If the values in our Weather Reports were reduced to 106 or 100 m. [348 or 328 ft.] above sea, the advantage quoted by Prof. M'Adie holds good by accepting *my* proposal; and for values read directly from the barometer, if no numerical or graphical corrections are applied, both methods of expressing the results (as points per thousand above or below the average) give merely rough approximations. For places below 50 m. in height M'Adie's would be better, for places above 50 m. mine would be better. But if corrections are applied, it is somewhat immaterial whether comparison is made with 1000 or with a greater quantity. In any case this matter appears to me to be of no great importance compared to the advantage of a rational measure applicable both to science and technology.

The following figures give the conversion of some values of the proposed measure into that at present in use. At sea-level, air-pressure ordinarily lies between 950 and 1050.

Mb. . .	200	400	600	800	950	1000	1013·3	1050	1080
Mm. . .	150·0	300·0	450·0	600·0	712·5	750·06	760·0	787·6	810·1
Inches .	5·91	11·81	17·72	23·62	28·05	29·53	29·92	31·01	31·89

It is not probable that the countries measuring air-pressure in millimetres will change their present system without very strong cause. People will not allow that the advantages of the new over the old are sufficiently great to justify them in upsetting the far-reaching agreement arrived at, after much trouble, on the Continent. Neither will they take upon themselves the inconvenience of the state of transition without forcible reasons. But if the countries using English measures take the lead in this direction, and if there be a well-grounded prospect of an agreement of the whole world in meteorological measures by the adoption of this proposal, then probably the countries using the metric system would willingly take upon themselves that inconvenience in return for this great advance; but only when by doing so a really rational uniform system is obtained. For purely empirical expedients an agreement could hardly be arrived at.

The reform need at first only be carried out as regards meteorology. Engineers, as well as physicists and chemists, will likewise presumably not be slow to profit by the many advantages that the new system also offers to them; but this can be left to time—meteorology need not postpone its introduction for a general agreement of all these branches of knowledge.—W. KÖPPEN, Hon. Mem. Roy. Met. Soc., Deutsche Seewarte, Hamburg, March 7, 1909.[1]

[It may be noted that from January 1, 1909, the Meteorological Office have in the *Weekly Weather Report* actually adopted, for recording the pressures in the upper air, the unit of one megadyne per square centimetre, which is exactly the same unit as Dr. Köppen's Bar. See *Weekly Weather Report* for 1909, vol. 26, Preface, p. 4.—EDITORS.]

International Balloon Ascents in 1909.

Dr. de Quervain and Dr. Stolberg propose to undertake, during the spring and summer of this year, an expedition to the west coast of Greenland. In addition to their other work they wish also to carry out aeronautical experiments

[1] Dr. Köppen's letter was written in German, and has been translated by Mr. J. S. Harding, F.R.Met.Soc. EDITORS.

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with both captive and pilot balloons. Dr. de Quervain has requested me to alter by a month the minor series of ascents for spring, because, in spite of all despatch, the travellers will not be able to commence their work in Greenland till March 31.

For this reason I propose to undertake an ordinary ascent on April 1, and to carry out the minor series on May 5, 6, and 7. The other dates will not be altered.

The following dates remain for the year 1909:—March 4; April 1; May 5, 6, and 7 (minor series of ascents); June 3; June 30, and July 1 and 2 (minor series of ascents); August 5; September 2; October 6, 7, and 8 (minor series of ascents); November 4; and December (great series of ascents).—H. HERGESELL, President, International Commission for Scientific Aerostation, Strassburg, *February* 9, 1909.

Freezing of the Wet-bulb Thermometer.

I noticed on March 1 a curious anomaly of temperature, which I cannot quite understand.

There being a frost, I visited my instruments in the Stevenson's screen at 8.30 a.m. in order to moisten the wet-bulb, but to my surprise I found that the covering of the bulb and the thread were both moist and unfrozen, and the reservoir was also quite unfrozen. The readings of the instruments were—minimum (during the night), 26°·0; dry-bulb, 27°·7; wet-bulb, 32°·2. I touched the muslin and the thread with a pipette to make sure I was not mistaken as to their being unfrozen, and whilst I was there the reservoir froze up, becoming cloudy throughout, owing to the formation of ice. I remoistened the wet-bulb, and returned at 9.20 a.m. to take the usual morning readings, when I found the wet-bulb frozen hard, and the readings—dry-bulb, 30°·2; wet-bulb, 28°·0, indicating a humidity of about 68 per cent. If the humidity were the same at the earlier reading the wet-bulb should have registered 26°·1, and I am at a loss to understand how the reading should have been 6° higher.

Would the heat given out in the act of freezing be sufficient to account for it? But even then it seems strange that the water should have remained unfrozen so long.—ARTHUR PEARSE JENKIN, Trewirgie, Redruth, *March* 3, 1909.

[In the *Quarterly Journal*, vol. 31, p. 54, Mr. W. Marriott gave a case in which he found the muslin and conducting thread to be *unfrozen* although the temperature of the air was 6° below the freezing-point. The actual readings were—dry-bulb, 26°·0; wet-bulb, 24°·6. Immediately after touching the conducting thread, both the thread and muslin became frozen, and the mercury in the wet-bulb forthwith ran up to 32°.—EDITORS.]

Cyclonic Thunderstorms of January 7 and 15, 1909.

A very short but violent thunder-squall passed over this district on the night of January 7. The weather previous to the disturbance had been overcast and squally. Towards 11.45 p.m. a dense, black cloud (cu.-nim.) moved up rapidly from the west, the wind increasing suddenly from West to almost gale force, accompanied by a marked moaning sound. There was a loud, rolling thunder-clap at 11.50 p.m. at zenith, torrential rain commencing at 11.52 p.m., the wind being estimated as force 7. The falling rain had a distinctly rotatory motion (as seen against an arc lamp), and was dashed to the ground with great force. A second clap of thunder occurred at 11.54 p.m. followed in one second by fork lightning of a red colour. Rain ceased at 11.58 p.m., and at 12 p.m. the wind had dropped to a light breeze from North-west; sheet lightning was seen to the south. There was a sudden increase in pressure amounting to ·03 in. and a fall in temperature of 6°. Rainfall yielded ·10 in. No hail fell, the path lying apparently to the northward.

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On January 15 a cyclonic thunderstorm occurred, remarkable for the number and intensity of the flashes of fork lightning (eleven in five minutes). After a day of continuous sunshine, steady rain set in at 9.40 p.m., developing into heavy rain at 11 p.m. Loud thunder was first heard in south-east at 11.12 p.m., vivid fork lightning being first seen at 11.13 p.m., the interval to thunder being twelve seconds, at 11.14 p.m., interval to thunder ten seconds, and 11.14½ p.m., five seconds interval. Between 11.15 and 11.18 p.m. no less than eight brilliant flashes of fork lightning were recorded, of a deep blue colour. The storm lay to the south-east, and travelled away in a southerly direction. There was no effect on the barographic trace.—SPENCER C. RUSSELL, Epsom, Surrey.

Meteorological Work at the Royal Observatory, Greenwich, 1908.

The meteorological observations by eye and by self-recording instruments have been maintained as usual, and the special observations of clouds on selected days in each month have been continued at the request of the International Balloon Committee, a Fineman nephoscope having been used for this purpose.

Daily reports have been issued as in previous years, weekly meteorological returns furnished to the Registrar-General, monthly returns of temperature, rainfall, and sunshine to the Society, and monthly reports to the Meteorological Office.

The temperature of the air ranged between 84°·0 on July 3, and 12°·1 on December 30. The summer, though fine, was thus not very hot, but the cold weather presented some unusual features. On eight days only during 1908 was a maximum temperature of 80° or more recorded in the shade. The remarkable snowstorm of April 23-24 was accompanied by exceptionally low temperature. It is a curious circumstance that since the closing of the 65 years' temperature summary in 1905, the mean temperature on April 24 has set up a fresh "record" each year, being in 1906 colder than on any April 24 in the 65 years, in 1907 warmer than any in the 66 years, and in 1908 much colder than any in the 67 years. A similar "coincidence" is found in respect of September 3, except that in this case 1906 provided the warmest, 1907 the coldest so far, and 1908 one colder still. Towards the end of the year other noteworthy periods presented themselves. New maximum "records" were set up for four successive days, September 30 to October 3; just as in 1906 four successive maximum records were set up from August 31 to September 3. Then on the night November 9-10 came the first air-frost of the season with a minimum reading 22°·1, which was not only lower than any officially recorded here in any season before the middle of November, but also very much lower than any reading obtained for the first frost of a season. Ten days later came another slight frost, and then no more until after Christmas, when a very remarkable frost, commencing with snow on December 27, and accompanied by a heavy fall on the 29th, lasted unbroken from about 9 a.m. on the 27th to 6 a.m. on the 31st, or little less than 96 hours, during which the thermometer reading fell to 12°·1 about 9 a.m. on the 30th, within 21 hours of a complete and lasting thaw. Than December 30, 1908, no colder day (mean temperature) can be found in any December in the 68 years of Greenwich official records. There have been three colder days in January, one each in 1841, 1867, and 1894, but there have only been five days with a lower maximum reading, and fifteen with a lower minimum, in the whole period.

Just as in 1907 in spite of the cold summer, the mean temperature for the year was very little below the normal, so in 1908 the mean temperature, in spite of the fine weather, was very little above the normal, being 49°·8 as against an average value of 49°·6 from 65 years' observations, the outstanding months being April, 3°·7 below the average, and February, May, October, and

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November, respectively 2°·3, 2°·9, 3°·9, and 3°·2 above the averages for those months.

The duration of sunshine recorded in the year was 1634 hours, or 132 hours more than the average of 10 years 1897-1906. To this total June contributed 261·6 hours, an amount only once exceeded in June (in 1877, the first year of complete sunshine records); October with 133°·3 hours and November with 76°·6 each exceeded the sunshine of any previous year for those months. Of individual days the sunniest, both in total duration and in percentage, was June 26 with 15·3 hours, or 93 per cent of the time the sun was above the horizon. Ninety per cent or more was also registered on July 1, July 29, August 12, September 30, October 30, and November 8. There were 63 days on which no register was obtained; more than half of these days were in January or December, none in June, one in September, two each in March, May, July, and August, and three in October.

The highest reading of the solar radiation thermometer with blackened bulb *in vacuo* was 147°·3 on June 26, already noted as the sunniest day, which also provided the greatest difference, 117°, between the maximum in the sun and the minimum on the grass. The lowest reading on the ground was 2°·0 on December 30—a reading equalled on Christmas Day 1860, but only once "beaten" during the 68 years by a reading of −0°·5 on February 12, 1845. On 19 days in 1908 the difference between the maximum in the sun and the grass minimum recorded 100°, as against 5 days in 1907, and 32 in 1906.

Air-temperatures of 32° or less were recorded on 49 days, most of them in January or March; February, April, and December each contributing 5, and November 3.

On the ground the number of days similarly counted with readings of 32° and under was 141, or 113 with readings of 30° and under, which correspond to only 96 nights.

Rain fell on 150 days in the year to the total amount of 23·784 ins., or ·338 in. less than the average for the 65 years 1841-1905. In the new comparison gauge with receiving surface 1 ft. from the ground instead of 5 ins., the amount measured was 23·421 ins. The driest month was November, with ·764 in., and the wettest July, with 3·664 ins., followed by August with 3·283 ins. The autumn months, September, October, and November, had less than 4 ins. total rainfall, being the driest autumn since 1890. The greatest daily falls were 1·041 ins. on July 13, ·954 in. on June 4, and ·950 in. on January 8; on 8 other days falls exceeding half an inch were recorded. Two droughts occurred, June 18 to July 3, and July 20 to August 4 inclusive.

The greatest recorded pressure of the wind was 20 lbs. to the square foot on February 22. The greatest daily velocity was 747 miles on March 10, and the least 61 miles on October 4. The greatest hourly velocity was 43 miles, for the hour ending 5 p.m. on February 22. The total movement for the year was 100,924 miles, the greatest monthly movement being 10,782 miles in February, and the least 5553 miles in October, a smaller mileage than in any October since the present instrument was set up (1867).

Very little progress has been made during the year with the discussion of the 40 years' homogeneous records of the Robinson Anemometer, but a considerable amount of time has been spent in preparing for a rainfall discussion for a period of 50 years to end with 1910.—[Sir] W. H. M. Christie, Astronomer-Royal, *February* 26, 1909.

Meteorological Work at the Radcliffe Observatory, Oxford, 1908.—The usual meteorological observations and automatic registrations have been maintained, and the results forwarded regularly, as heretofore, to the Meteorological Office (by daily telegram), the Registrar-General, the Thames Conservancy,

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the Metropolitan Water Board, local newspapers, to public and sanitary authorities, and numerous private inquirers.

During the year 1908 the five underground platinum thermometers were read daily. Observations made with these thermometers have been carried on without interruption since November 1, 1898, but it is intended to discontinue their regular use at the end of 1909. At the request of the Director of the Meteorological Office, daily comparisons have been made between the platinum thermometers and two ordinary mercurial thermometers of Symons' underground pattern, at depths of 6 ins. and 3 ft. 6 ins.

All the automatic instruments have worked well during the year.

The following are the chief characteristics of the weather noted at Oxford during the year 1908 :—

The mean reading of the barometer (reduced to 32° F.) was 29·790 ins., which is ·063 in. higher than the mean for the preceding 53 years. The highest reading, 30·509 ins., occurred on February 6; the lowest was 28·612 ins. on December 11.

The mean temperature of the air for the year was 49°·3, or 0°·5 above the mean for the preceding 80 years. The maximum temperature was reached on July 3, viz. 83°·6; and the minimum, 9°·4, on December 30. The lowest reading of the thermometer exposed on the grass was 4°·7 on December 30.

The differences of the mean monthly temperatures from the corresponding means for the preceding 80 years are :—

January .	−1°·7	May . .	+3°·1	September . .	−0°·4
February .	+2·7	June . .	+0·9	October . .	+3·7
March . .	−1·5	July . .	+0·2	November . .	+3·2
April . .	−3·6	August .	−0·9	December . .	−0·1

Bright sunshine was recorded during 1536 hours, or 73 hours above the mean for the preceding 27 years. The monthly differences from the mean are indicated in the following table :—

	hours.		hours.		hours.
January . .	+ 9	May . .	+ 7	September . .	−18
February .	+ 2	June . .	+68	October . . .	+16
March . .	−34	July . .	+ 7	November . .	+15
April . . .	−18	August .	+31	December . .	−12

Rainfall on the ground amounted to 23·725 ins., a total which is 2·314 ins. below the average for the preceding 93 years. The number of "rain days" (*i.e.* ·010 in. and over) was 141. The divergencies of the monthly totals from the corresponding mean values for the previous 93 years were :—

	ins.		ins.		ins.
January .	−0·284	May .	−0·515	September . .	−0·907
February .	−0·754	June .	−0·630	October . .	−1·708
March .	+1·095	July .	−0·419	November . .	−1·239
April . .	+2·552	August .	+0·568	December . .	−0·073

Solar and lunar halos have been frequently observed during the year; on April 29 and September 3 the halos seen were more than usually interesting, as they were accompanied by multiple parhelia.

Displays of aurora happened on September 14 and 29, and November 19.

A special feature in the weather of 1908 was the manifestation of extraordinary conditions and rapid changes during the closing days of April and the first two days of May. For the time of year, as far as our records have been consulted, the conditions prevailing in this interval are quite unprecedented, and were briefly as follows :—On April 23, rain, snow, and sleet had freely alter-

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nated ; but April 24 was, until 3 p.m., brilliantly fine, no less than 8½ hours of bright sunshine being recorded. The maximum air-temperature (41°·5) was recorded at 3 p.m., and almost immediately afterwards the fair weather terminated, and snow began to fall in frequent showers. A heavy snowstorm commenced at 10·30 p.m. and persisted during the succeeding 24 hours, until there was an average depth of 17 ins. The early fruit-trees were in bud and blossom, and these, together with ornamental trees and shrubs, were much damaged by the weight of accumulated snow. Sunrise on April 26 induced a rapid thaw, and the temperature rose rapidly to 49°·4. After a brief interval of 5 days, another record was established by the air-temperature running to 76°·4. This maximum is 9°·4 higher than the mean of the absolute maxima for the month of April as recorded at Oxford during 48 years, and is even 2°·9 higher than the corresponding mean for the whole of May.—ARTHUR A. RAMBAUT, Radcliffe Observer, *March* 2, 1909.

Temperature and Rainfall at Pemba, E. Africa.

The island of Pemba is situated on the east coast of Africa, about five degrees south of the Equator, and just north of Zanzibar. Its chief industry is the growth of cloves ; this is largely in the hands of Arabs who cultivate with slave labour. It is under British Protectorate. When some years since there commenced a movement for the manumission of the slaves, the Society of Friends in England sent out Mr. Theodore Burtt, an expert Lincolnshire farmer, to aid the slaves as they received their freedom. He purchased plantations and has been growing cloves with freed labour. He is now planting rubber, but this has not gone beyond the experimental stage.

Mr. Burtt soon began to take regular notes and observations of rainfall and temperature, and some of these have been published both in *Symons's Meteorological Magazine* and in the *Quarterly Journal*. He has now sent the following summary of the nine years 1899 to 1907 :—

SUMMARY OF METEOROLOGICAL OBSERVATIONS TAKEN AT BANANI, ISLAND OF PEMBA, EAST AFRICA, 1899-1907.

YEARS.	Temperature.					Rainfall.	
	Mean Max.	Mean Min.	Absolute Max.	Absolute Min.	Extreme Range.	Amount.	No. of Days.
	°	°	°	°	°	ins.	
1899 . .	83·3	70·2	92·0	65·0	27·0	105·24	149
1900 . .	83·5	71·3	95·0	66·0	29·0	90·35	160
1901 . .	81·8	70·4	90·5	65·0	25·5	92·78	166
1902 . .	82·8	71·4	91·0	67·0	24·0	68·72	132
1903 . .	82·3	71·3	91·5	66·0	25·5	63·24	136
1904 . .	81·0	70·4	90·5	65·0	25·5	86·23	156
1905 . .	81·6	71·3	90·5	64·0	26·5	101·28	153
1906 . .	81·4	70·5	92·0	64·0	28·0	108·58	178
1907 . .	81·5	70·2	89·0	63·0	26·0	76·23	177
Mean . .	82·1	70·8	95·0	63·0	32·0	88·07	156

Sun temperature in January is 175°, in July 150°.

The extreme range of temperature in the nine years is 32°. The absolute maximum varies only from 89° to 95°, and the absolute minimum from 63° to 67°. In rainfall there is considerable variation. From 105·24 ins. during 1899, it sank gradually to 63·24 ins. during 1903 ; it then increased again to 108·58 ins. during 1906. The rain days vary in number from a minimum of 132 in the year 1902 to a maximum of 178 in 1906.

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The climate is not a happy one for Europeans. Mr. Burtt's work soon grew, so that helpers were sent out, and for some years a regular mission has been established on the island. Home furloughs at intervals of a few years are necessary; some missionaries have died; others have become so invalided (Mr. Burtt's wife among them) as to render return highly imprudent. The observer is not therefore always the same. It is interesting to note that one missionary continues in the perfect health which he enjoyed in England.—T. P. NEWMAN.

Thunderstorm at Portsmouth, February 14, 1809.

The Times newspaper of February 17, 1909, reprinted the following article from *The Times* of the same date, 1809:—

"REMARKABLE OCCURRENCE.

"We have been favoured with the perusal of a letter from on board the *Warren Hastings*, recently launched at Portsmouth, and now moored at the Mother Bank, which states a singular occurrence that took place on board of that ship on the 14th instant, for the truth of which we can vouch:—

"The morning being fine, it was deemed necessary to get up the top-gallant masts, which occupied some hours. About three o'clock in the afternoon the atmosphere was overcast to the westward, and every appearance indicated the approach of a violent storm. Several alert sailors were sent aloft to strike the top-gallant masts as speedily as possible, but while lowering them the wind blew tremendously, and the rain fell in torrents, accompanied by heavy claps of thunder. In the midst of the confusion occasioned by the storm, three distinct balls of fire were emitted from the heavens; one of them fell into the main-topmast cross-trees, killed a man on the spot, and set the main-mast on fire, which continued in a blaze for about five minutes, and then went out. The seamen both aloft and below were almost petrified with fear. At the first moment of returning recollection, a few of the hands ran up the shrouds to bring down their dead companion, when the second ball struck one of them, and he fell, as if shot by a cannon, upon the guard iron in the top, from which he bounded off into the cross jack braces. Finding that he still survived, he was relieved from his perilous situation, and brought upon deck with his arms much shattered and burnt. This poor fellow was expected to undergo immediate amputation, as the only means of saving his life. The third ball came in contact with a Chinese, killed him, and wounded the main-mast in several places; the force of the air, from the velocity of the ball, knocked down Mr. Lucas, the chief mate, who fell below, but was not much hurt. For some time after the storm subsided, a nauseous, sulphureous smell continued on board the ship.

"A report prevailed at Portsmouth on Tuesday, that eight of the crew had been killed; but the above account may be depended on as the most accurate."

Luke Howard in his *Climate of London*, 2nd edition, vol. 2, p. 69, gives the following notes for February 14, 1809:—

"During a heavy storm of wind, accompanied by thunder, rain, and hail, the house of a baker in New Navy Row, Plymouth Dock, was struck by lightning, and together with the two adjoining houses materially damaged. On the same day at Paris, the barometer being just past the minimum for the month, the wind very strong at West with much rain, there was thunder at 6 p.m., and a house near the city was struck by lightning. A portion of the bell-wire in this house was dispersed and fixed as a very extensive *stain* in the wall of the apartment: one portion of the iron being thrown off each way, at right angles from the course of the wire, in mossy ramifications; and another above it, more perfectly dissipated, in a figure resembling an electrified lock of hair in the midst of a cloud of smoke. The stain measured six feet by four."

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Thunderstorms in Germany.

The *Abhandlung*, Band II., No. 2, of the Royal Prussian Meteorological Institute, is devoted to an elaborate discussion, by Mr. T. Arendt, of the thunderstorm observations made in North and Central Germany during the 10 years 1887-1896. The number of stations from which returns were used, and also the average number of thunderstorms per station in each of these years, were as follows :—

	Stations.	Thunderstorms per Station.		Stations.	Thunderstorms per Station.
1887 . .	1100	14·8	1892 . .	1418	26·9
1888 . .	1338	21·0	1893 . .	1403	27·2
1889 . .	1321	32·2	1894 . .	1376	27·7
1890 . .	1241	30·5	1895 . .	1345	32·2
1891 . .	1437	33·2	1896 . .	1331	29·7

The mean monthly distribution of thunderstorms in the various districts was—

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
West German Highland .	0·06	0·05	0·47	1·12	3·25	4·36	6·00	4·45	1·32	0·52	0·15	0·14
Schleswig-Holstein .	0·01	0·11	0·36	0·85	2·49	2·93	4·42	3·74	1·35	1·11	0·25	0·19
Highland, between Elbe and Oder .	0·02	0·07	0·53	1·55	3·30	4·53	5·57	4·15	1·37	0·34	0·04	0·09
East German Highland .	...	0·04	0·34	1·54	4·05	4·47	5·64	4·18	1·44	0·37	0·02	0·03
Rhine Mountainland .	0·04	0·06	0·48	1·17	3·71	5·31	5·57	4·16	1·60	0·48	0·03	0·10
Central Germany. .	0·05	...	0·56	1·16	3·50	4·89	5·53	3·72	1·25	0·25	0·03	0·07
Silesian Mountainland	0·02	0·03	0·17	1·60	5·04	5·50	6·08	4·11	1·84	0·58	...	0·02

The time of the greatest frequency of thunderstorms is between 3 and 5 p.m. There are, however, secondary maxima between 8 and 10 p.m., and also in the early morning hours.

Meteorological Conditions controlling the Nile Flood.

Mr. J. I. Craig gives in the *Cairo Scientific Journal* a report on the expedition which was sent by the Egyptian Survey Department to Addis Abbaba in 1907 "to study the meteorological conditions controlling the Nile Flood." This place was selected for the seat of observations, for, although not in the basin of the Nile, it was sufficiently near to make it highly probable that the conditions in the basin of the Blue Nile would be similar to those observed. Addis Abbaba was reached on June 15, and the rains did not commence until July 2. They may be said to have ceased on September 20, and the expedition left on the return journey on October 25, so that there was an opportunity of comparing the weather of the dry season with that of the rain. As it happened, the Nile Flood of 1907 turned out to be the worst there has been for 40 years.

Mr. Craig summarises the results as follows :—The rainfall may be divided into two classes, one a light but persistent drizzle, similar to that known in Britain as a "Scotch Mist," the other of the nature of a heavy but intermittent downpour. The first is probably purely orographic, the second mainly associated with thunderstorms. In the latter case, however, it may be considered

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that the mountain-range produces an effect in bringing the air-masses to the point of saturation, and thus preparing them for the action of the convectional ascensional movement. This rainfall was usually associated with South or South-westerly winds; but the direction of approach of the thunder squalls was generally from north-east or east, which appeared to be the direction of the upper currents. There is a well-marked diurnal periodicity in the rainfall, with a maximum in the afternoon, and secondary maxima in the morning before sunrise, and in the evening about an hour after sunset. On days of normal rainfall the late morning hours were usually fine, but, with remarkable regularity at 12.30 p.m. the first thunder would be heard, followed about 1 p.m. by the first rain. After several heavy showers, sometimes accompanied by heavy falls of hail, the thunderstorm would pass away to the south-west or west, and the evening would be fine, but frequently with a recrudescence of the thunder and rain after sunset. The chief rainfall was therefore associated with, but not necessarily caused by, electrical disturbance. The evening maximum is in all probability to be attributed to the radiation that must commence to act strongly as soon as the upper surface of the saturated air forming the cloud layer is deprived of the warmth of the sun's rays. The early morning rainfall was probably caused by radiation also, but this point is more obscure. The intensity of the rainfall varied much locally, and was much influenced by the direction taken by the thunder squalls, which again appeared to be influenced by the position of the surrounding hills with respect to the town. The squalls sometimes advanced along the hills to the south, in which case the eastern end of the town was outside their influence, while the western end came within it. Thus the rainfall at the latter was in general heavier than at the former. The general conclusion appears to be that the determining cause of the rainfall is the ascensional movement with which thunderstorms are associated. But the total fall of rain in a day will be influenced not only by the ascensional movement, but also by the absolute amount of moisture near the saturation point, in the air; and also by the rate at which the moist air is supplied.

Accounts from all parts of Abyssinia, from Shoa south to the country of the Arussi, agree in stating that the intensity of electrical phenomena was much greater in 1907 than it had been for many years. This appears to prove that the ascensional movement was greater than of late years, a condition favourable to heavy rainfall. If the rains failed, as they undoubtedly did, the reason is to be sought probably in the contributory conditions, the total amount of the moisture and the rate of supply. The question of the absolute water-content of the air is still under consideration; but as regards the rate of supply, observations in the Sudan show that wind-force in August and September was notably below normal. This would go to prove that the velocity of the supply-current was much less than usual, with a resulting prejudicial effect on the total rainfall. A further cause of deficiency of the rainfall, although the evidence here is less clear, will be found in the probable northward extension of the Kharif air-current in 1907, which would indicate that a part of the current was diverted round to the north of the Abyssinian plateau, in place of over it as usual. There is some evidence that the North-east trade wind in Egypt was weaker than usual in the summer of 1907. It is fairly clear that this North-east wind must rise over the damper but colder, and therefore on the whole heavier, air of the South-western current, which becomes more Westerly in the north Sudan. The consequence must be an action by the trade wind on this current, tending to push the latter southward. A well-developed trade wind would, on this hypothesis, lead to a migration of the Kharif current southwards, while a weak trade would favour a northerly migration. It appears probable that this is what happened in 1907, and accordingly that, a portion of the

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moisture-bringing current having been diverted to the north of the plateau, the total supply of moisture in the basin of the Blue Nile was less than usual. Another possible reason for the variation of the rains is to be found in the changing thickness of the moist current, but this point is still under consideration, and, further, is this year [1908] being attacked directly by kite and balloon observations.

It may not be inappropriate to add a word on the place of origin of the moisture-laden current. Various considerations show that in the neighbourhood of the Abyssinian plateau the prevailing direction of the current is from West or more generally South-west. Observations of wind direction in the Sudan during the period of the Kharif bring this out clearly, and the same prevalence is to be found at places on or near the east coast, like Lugh and Jibuti. Further north, at Suakin, the prevailing direction becomes Westerly, and on the higher plateau, as at Adua and Addis Abbaba, there is an alternation of North-east and South-west winds during the season of the heavy rains. The explanation of this phenomenon is probably to be found in the variation of thickness of the South-west current. When this current is deeper than usual, it lifts the North-easterly current above the plateau, but as it becomes shallower it allows the upper current to sink on to the higher part of the plateau. The end of the rainy season is signalled by the commencement of a steady, dry Easterly current at Addis Abbaba, long before the South-westerly wind has ceased in the Sudan. Thus wind-observations on both sides of the plateau point to the prevalent direction as being South-westerly. A similar conclusion is reached when one compares hydrographically the western side of the plateau with the eastern. The rivers rising on the former are much more important than those on the latter, from which it may naturally be inferred that the rainfall is heavier on the western side, and consequently that this is the windward side of the plateau. Observations and reports agree that the South-west wind is the wettest in Abyssinia. These facts tend to prove that the current which supplies the moisture must come from the South-west. Let, then, this current be traced backwards across Africa. Observations are scarce over the basin of the Congo, but such as there are point to the existence of a Westerly or South-westerly current there also at this season. Similarly on the West Coast of Africa the prevalent wind direction during the northern summer is still Westerly or South-westerly. The conclusion is inevitable that the current comes from the South Atlantic, and that it there obtains the moisture which is precipitated in Abyssinia, and ultimately finds its way to Egypt as the Nile Flood. This theory bears on only one factor of the rainfall, the supply of the moisture. The velocity of the current would still be in great part determined by the isobaric gradients of the great monsoon depression, and finally the convectional ascensional movement would probably require separate discussion.

Dew-Ponds.

In an interesting paper on "Dew-Ponds," read before the Royal Society of Arts on March 3, 1909, Mr. George Hubbard said that the essential difference between a dew-pond and an ordinary pond lies in the fact that an ordinary pond obtains its water-supply from springs or surface-water drainage; but the dew-pond, owing to its special form of construction and the nature of the materials used in it, will condense the moisture from the air. As the air is present all over the surface of the earth, the question which presents itself to the practical mind is, whether dew-ponds could with advantage be introduced into waterless lands? To predict the answer to this question it is necessary to know, not only the temperature of air as measured by the dry- and wet-bulb thermometers, but also the radiating power of the surface of the pond.

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Regarding the construction of a dew-pond, the author states that operations are commenced by hollowing out the earth for a space far in excess of the apparent requirements of the proposed pond. The whole of the hollow is then thickly covered with a coating of dry straw. The straw in its turn is covered by a layer of well-chosen finely-puddled clay, and the upper surface of the clay is then closely strewn with stones. Care must be taken that the margin of the straw is effectively protected by clay.

The pond will gradually become filled with water, the more rapidly the larger it is, even though no rain may fall. If such a structure is situated on the summit of a down, during the warmth of a summer day the earth will have stored a considerable amount of heat, while the pond, protected from the heat by the non-conductivity of the straw, is at the same time chilled by the process of evaporation from the puddled clay. The consequence is that during the night the moisture of the comparatively warm air is condensed on the surface of the cold clay. Owing to the chilling effect of evaporation from this thermally isolated surface, the condensation during the night is in excess of the evaporation during the day, and the pond becomes, night by night, gradually filled. The dew-pond will cease to attract the dew if the layer of straw should get wet, as it then becomes of the same temperature as the surrounding earth, and ceases to act as a non-conductor of heat.

Composition of Barbados Rainfall.

In the "Report on Agricultural Experiments," which were conducted in Barbados in the season 1905-1907 under the direction of the Imperial Department of Agriculture for the West Indies, particulars are given of the amount and composition of the rainfall at Dodds Botanic Station. Fortnightly samples were analysed at the Government Laboratory. The total amount of rainfall from December 1905 to May 1907 was 76·53 ins., and this supplied approximately 175 pounds of chlorine and 9·5 pounds of nitrogen per acre.

Month.	Rainfall.	Parts per Million of			
		Chlorine.	Nitrogen as Ammonia.	Nitrogen as Nitrates.	Nitrogen. Total.
	Inches.				
December 1905	2·28	23·0	·021	·281	·302
January 1906	1·64	19·0	·049	·854	·903
February ,,	1·29	26·0	·092	1·750	1·842
March ,,	·90	21·5	·127	·647	·774
April ,,	·89	31·0	·143	·606	·749
May ,,	1·30	26·0	·064	·162	·226
June ,,	11·26	8·0	·014	·318	·332
July ,,	5·88	9·8	·051	·163	·214
August ,,	5·99	12·0	·038	·229	·267
September ,,	11·27	7·0	·014	·817	·831
October ,,	10·24	7·0	·033	·576	·609
November ,,	9·41	Contaminated.			...
December ,,	4·49	10·0	·040	·471	·511
January 1907	1·93	10·0	·054	·162	·216
February ,,	2·97	12·5	·031	·801	·832
March ,,	1·60	13·5	·042	1·130	1·172
April ,,	1·74	14·0	·040	·080	·120
May ,,	1·45	13·0	·038	·396	·434
Total	76·53	...	...	...	...

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Humidity in Cotton-Weaving Sheds.

In November 1907, the Home Secretary appointed a Departmental Committee to inquire into the subject of Humidity and Ventilation in Cotton-Weaving Sheds. Sir Hamilton P. Freer-Smith was appointed Chairman. The Committee have now issued their Report. Among their recommendations are the following relating to humidity :—

1. That in view of the generally expressed opinion of physiologists that the health and comfort of the workers is dependent on the wet-bulb temperature, rather than on the dry-bulb temperature, or the relative, or the absolute humidity, a limit of temperature on the wet-bulb thermometer be fixed at which all admission of artificial humidity shall cease, this limit to be decided by early experiments and to be the lowest necessary for efficient weaving.

2. That the present schedule of humidity be amended by eliminating all temperatures above the maximum wet-bulb reading to be hereafter determined and all temperatures below 50° F., on the dry-bulb, and that a minimum difference between the readings of the dry- and wet-bulb thermometers be fixed when the maximum wet-bulb temperature has been decided.

8. That in order to secure general confidence, the readings of the thermometers to be taken jointly by representatives of the employer and employed, and that a statement relating to these readings be entered in a register to be kept at the works and to be examined by H.M. Inspectors of Factories, but that records be sent to the Home Office only when irregularities are found, and the practical details be settled by conference between official representatives of the Manufacturers' and Operatives' Associations.

9. That power be given to the Secretary of State to prescribe a standard hygrometer, that distilled water only be used, kept sufficiently long in the shed to acquire the shed temperature, and that provision be made to prevent the wet-bulb moisture affecting the dry-bulb thermometer.

RECENT PUBLICATIONS.

Lightning and the Churches. By ALFRED HANDS. London: J. W. Gray and Son, 1909. 8vo. 92 pp. 1s.

This book has been written with the object of calling attention to the fact that churches are most frequently struck by lightning owing to inefficient conductors, or to conductors that may have deteriorated through the effects of time. The author points out that the lightning conductor system should be inspected and tested periodically by an expert.

Mr. Hands states that he is compiling a chart of England and Wales showing the places where damage by lightning has occurred, and also the nature of the objects struck. During the period from 1897 to the commencement of 1908, there were 7793 instances of damage, which were distributed as follows :—

211 cathedrals, churches, and chapels.
3190 other buildings of various kinds.
226 ricks and stacks.
1251 trees.
194 persons killed.
1016 persons injured.
1307 cases in which animals were killed.
398 objects not covered by the foregoing classes.

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As regards the animals killed, it is pointed out that the cases vary from single ones to as many as 49 in a flock, and by one stroke of lightning, and that the total number killed during this period would probably amount to 5000 or more.

Mr. Hands estimates that the monetary loss varies from £50,000 to £100,000 per annum, but these figures may be far below the real value, for the cost of reinstating is often very much greater than would have been expected from an inspection of the structure immediately after the accident.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of more general interest.

Alfani, P.—Le Grand Baromètre de l'exposition de Faenza. *Ciel et Terre, Brussels*, **29**, 1908 (483-493).

Angot, M. A.—La Vie et les travaux de M. Mascart. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (229-237).

Ashworth, J. R.—An Analysis of the Meteorological Elements of Rochdale. Reprinted from *Trans. Rochdale Lit. and Sci. Soc., Rochdale*, 1908.

Bamler, K.—Scientific Ballooning and Weather Forecasts. Translated from *Illust. Aeron. Mitt.*, 12, 1908 (29-33), by Prof. A. G. M'Adie. *Monthly Weather Rev., Washington*, **36**, 1908 (283-284).

Benham, C. E.—A New Method of Collecting Atmospheric Electricity. With a Description of the Relay Electroscope. *Knowledge, London*, **5**, 1908 (279-280).

Bigelow, F.—Studies on the Vortices of the Atmosphere of the Earth. The De Witte Typhoon, August 1-3, 1901. *Monthly Weather Rev., Washington*, **36**, 1908 (328-333).

Brendel, M.—Über das Nordlicht vom 30. Juni. *Meteor. Zeits., Brunswick*, **25**, 1908 (552-555).

Caron, E.—Note sur les lueurs crépusculaires au coucher du soleil. *Ann. Soc. Mét. de France, Paris*, **56**, 1908 (253-255).

Chetwynd, L.—Results of Magnetic Observations at Stations on the Coasts of the British Isles, 1907. *Proc. Roy. Soc., London*, **81**, 1908 (475-476).

Clayton, H. H.—The Scientific Aspect of a Balloon Voyage. *Monthly Weather Rev., Washington*, **36**, 1908 (296-297).

Cœurdevache, P.—Éléments météorologiques à Perpignan suivant les cartes du temps. *Ann. Soc. Mét. de France, Paris*, **56**, 1908 (256-257).

D(arwin, Sir), G. H.—(Obituary Notice of) Lieutenant-General Sir Richard Strachey, G.C.S.I., 1817-1908. *Proc. Roy. Soc., London*, **81**, 1908 (84-93).

Davis, H.—The Application of the Hygrometer in Coal Mines. Excerpt from *Trans. Inst. of Mining Engineers, Newcastle-on-Tyne*, 1908.

Dechevrens, M.—Les Phénomènes de température dans les tourbillons et en particulier dans la haute atmosphère. Reprinted from *Mem. del Pont Accad. Romana, Rome*, **26**, 1908.

Diaz, S.—Un Temporal de Invierno. *Mem. Soc. Cient. Antonio Alzate, Mexico*, **26**, 1908 (359-368).

Doane, F. W. W.—Meteorological Notes. *Trans. Nova Scotian Inst. of Sci., Halifax*, **11**, 1908 (361-372).

Doane, F. W. W.—The Frost and Drought of 1905 in Nova Scotia. *Trans. Nova Scotian Inst. of Sci., Halifax*, **11**, 1908 (623-639).

Field, F. H.—Ein neue Form des Meteorographen und anderer Apparate zum Gebrauch für Drachenaufstiege. *Meteor. Zeits., Brunswick*, **25**, 1908 (491-496).

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Freybe, O.—Der Wetterdienst im Winter. *Wetter, Berlin*, **26**, 1909 (21-24).

Gregg, W. R.—Recent Auroral Displays and Magnetic Disturbances. *Bull. Mount. Weather Obs., Washington*, **1**, 1908 (232-236).

Hann, J.—Mossman über die meteorologischen Ergebnisse der schottischen antarktischen Expedition. *Meteor. Zeits., Brunswick*, **25**, 1908 (530-542).

Harding, H. H.—The Weather of 1908 (over the British Isles). *J. Horticulture, London*, **58**, 1909 (89-91).

Henry, A. J.—Notes on the Climate of Eastern Asia. *Monthly Weather Rev., Washington*, **36**, 1908 (364-368).

Hellmann, G.—Die Anfänge der Meteorologie. *Meteor. Zeits., Brunswick*, **25**, 1908 (481-491 and pl.).

Hellmann, G.—Über die extremen Schwankungen des Regenfalls. *Zeits. Gesell. f. Erdkunde, Berlin*, **1908** (605-613).

Humphreys, W. J.—Note on the Magnetic Effect of Winds. *Terrestrial Magnetism, Baltimore*, **13**, 1908 (153-154).

Huntington, E.—The Climate of the Historic Past. *Monthly Weather Rev., Washington*, **36**, 1908 (359-364).

Joester, K.—Die Föhnerscheinungen im Riesengebirge. *Wetter, Berlin*, **25**, 1908 (250-254, 273-280), **26**, 1909 (14-17).

Jones, R. Ll.—A Discussion of some of the Anemographic Observations recorded at Madras. *Indian Met. Memoirs, Simla*, **20**, 1908 (74-116 and 6 pl.).

Kähler, K.—Registrierungen des luftelektrischen Potentialgefälles an nahe benachbarten Stationen. *Meteor. Zeits., Brunswick*, **26**, 1909 (10-17).

Kassner, C.—Bericht über die elfte allgemeine Versammlung und Feier des 25-jährigen Bestehens der Deutschen Meteorologischen Gesellschaft zu Hamburg am 28. bis 30. September 1908. *Meteor. Zeits., Brunswick*, **26**, 1909 (2-10).

Kienast, Prof.—Wettervoraussage vor 180 Jahren. *Wetter, Berlin*, **25**, 1908 (265-273).

Kimball, H. H.—Pyrheliometer and polarimeter observations. *Bull. Mount Weather Obsy., Washington*, **1**, 1908 (207-232).

Kleinschmidt, E.—The Kite Station on Lake Constance. *Monthly Weather Rev., Washington*, **36**, 1908 (284-285).

Lindemann, A.—Die grössten Tagesmengen des Niederschlags im Königreich Sachsen, von 1866 bis 1905. *Wetter, Berlin*, **26**, 1909 (10-13).

Livingston, Mrs. G.—An Annotated Bibliography of Evaporation. *Monthly Weather Rev., Washington*, **36**, 1908 (301-306, 375-388).

M'Adie, A. G.—Suggested Reform in Meteorological Methods. *Monthly Weather Rev., Washington*, **36**, 1908 (372-374).

MacKay, A. H.—Phenological Observations in Nova Scotia and Canada, 1904. *Trans. Nova Scotian Inst. of Sci., Halifax*, **11**, 1908 (373-386).

Marvin, C. F.—A Mercurial Barograph of High Precision. *Monthly Weather Rev., Washington*, **36**, 1908 (307-313).

Massarini, I.—I Venti a Roma. *Ann. de R. Uff. Cent. di Meteor. e Geodynamica*, **27**, 1905. *Rome*, 1908, Part 1 (1-89, 9 pl.).

Meisner, O.—Wahrheit und Irrtum in den Bauernregeln. *Wetter, Berlin*, **25**, 1908 (241-247).

Memery, H.—Les Hivers rigoureux et leur cause probable. *Ann. Soc. Mét. France, Paris*, **56**, 1908 (258-261).

Mill, H. R.—The Rainfall of 1908. *The Times, London*, Jan. 16, 1909.

Mill, H. R.—Sunshine for January (1909) in London. *Symons' Met. Mag., London*, **44**, 1909 (7-8).

Mossman, R. C.—The Cold Period of May in Arctic and Antarctic with Special Reference to 1903. *Symons' Met. Mag., London*, **44**, 1909 (1-6).

Mylius, E.—Über Böen und Gewitter. *Wetter, Berlin*, **26**, 1909 (1-10).

Neifert, W.—Installation of Automatic River Stage Register at Hartford, Conn. *Monthly Weather Rev., Washington* **36**, 1908 (340-342).

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Newcomb, S.—The Meteorology of Mars. *Monthly Weather Rev., Washington*, **36**, 1908 (342-343).

Polis, P.—Drahtlose Telegraphie und Wetterdienst. *Das Wetter, Berlin*, **25**, 1908 (285-288).

Rosenthal, E.—The Meteorological Work of the University of Jurjev (Dorpat), Russia. *Monthly Weather Rev., Washington*, **36**, 1908 (297-299).

Rykatschew, M., jun.—Über den Einfluss der Unterlage auf den täglichen Gang der absoluten Feuchtigkeit. *Meteor. Zeits., Brunswick*, **25**, 1908 (501-510).

Salter, C.—The Rainfall of Java. *Symons' Met. Mag. London*, **43**, 1909 (227-230).

Schmidt, W.—Zur Erklärung der gesetzmässigen Verteilung der Tropfengrössen bei Regenfällen. *Meteor. Zeits., Brunswick*, **25**, 1908 (496-500).

Schulze, P.—Ludwig Friedrich Kämtz. *Wetter, Berlin*, **25**, 1908 (247-250).

The Upper Atmosphere: the Results of Daily Experiments made at Glossop, Derbyshire. *The Airship, London*, **1**, 1908 (10 : 25).

Thorade, H.—Über die kalifornische Meeresströmung. Oberflächentemperaturen und Strömungen an der Westküste Nordamerikas. *Ann. der Hydrog. u. marit. Met., Berlin*, **37**, 1909 (17-34).

Varney, B. M.—Early Meteorology at Harvard College. *Monthly Weather Review, Washington*, **36**, 1908 (286-290).

Ward, R. de C.—Government Meteorological Work in Brazil. *Monthly Weather Review, Washington*, **36**, 1908 (290-291).

Ward, R. de C.—Notes on Weather and Climate made during a Summer Trip to Brazil, 1908. *Monthly Weather Review, Washington*, **36**, 1908 (333-339).

Wien, W.—Gesetze und Theorien der Strahlung. *Meteor. Zeits., Brunswick*, **25**, 1908 (542-549).

Zahm, A. F.—Résumé of experiments in Aerodynamics. *Monthly Weather Review, Washington*, **36**, 1908 (277-281).

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MEETINGS IN 1909-1910.

November	7.30 p.m.	17, 1909	March	7.30 p.m.	16, 1910
December	„	15, „	April	„	20, „
January	„	19, 1910	*May	4.30 p.m.	18, „
February	„	16, „	*June	„	15, „

January 19, 1910.—Annual General Meeting.

The Meetings will be held at the Institution of Civil Engineers, Great George Street, Westminster, S.W., except those marked with an asterisk (*), which will be held at the Society's Rooms, 70 Victoria Street, S.W.

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WIND-WAVES IN WATER, SAND, SNOW, AND CLOUD.

By VAUGHAN CORNISH, D.Sc., F.R.G.S., F.G.S., F.C.S.

[A Lecture delivered before the Royal Meteorological Society, March 17, 1909.]

WAVES IN WATER.

WHEN water is in travelling waves and the air is blowing over them, there is a travelling air-eddy between each pair of wave-crests. Its existence is forcibly demonstrated when a sailing ship, running before the wind in a big seaway, loses the breezes in the troughs of the sea, her sails flapping idly or being taken aback. Above the system of travelling air-eddies the particles of the air must move in a continuous undulation. The travelling eddies revolve between the corrugated water-surface below and the corrugated air-surface. The undulating movement of the air-particles must be less strongly marked as the height above the water increases, until at some elevation they are moving in straight paths.

The evolution of the great storm-waves of the deep ocean is coincident with the gradual creation of a regular series of superincumbent air-undulations.

When wind begins to blow upon a sheet of smooth water, *i.e.* when the flat bottom surface of air begins to slide upon the flat upper surface of water, it is not easy to make out either by observation or by mere common-sense reasoning what initiates a waved condition. What actually happens, as far as the eye can perceive, is that the whole water-surface is immediately covered with a remarkably uniform pattern of small waves of about the size (0·68 inch wave-length) of the slowest moving water-wave, and that, whereas close under the windward shore the waves remain always of this size, farther out they increase in size as the wind goes on blowing. The farther the distance from the windward shore the longer is the time required to develop the waves to the maximum size which the actual velocity of the wind is capable of maintaining, and the greater is the maximum height and length. Further, it is

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important to note that the increase in average wave-length (as we proceed in our down-wind inspection of the final result) is so gradual, that if we regard any small group of, say, a dozen succeeding waves, there will be no such difference as the eye would notice in the wave-length of the first half-dozen and of the second half-dozen. Theoretically, water-waves of all speeds, and therefore of all lengths, are created at once when wind blows over deep water, and of these waves all can be developed which move with a speed no greater than that of the wind; but actually no water-wave has a chance of developing to steepness at any place which does not conform to the length of the existing air-undulations at that place. Viewed in this way we see how gradual and slow is the process of evolution of a large type of waves from the action of wind on smooth water, the process involving very numerous adjustments whereby the air is brought into regular undulations, and the water into undulations conformable thereto.

When a storm ceases, the ocean remains heaving in waves, which travel by gravity, and the shorter of these flatten out quickly, leaving the longer ones relatively steep. Especially is this the case in high southern latitudes where the ocean is circumterrestrial with neither windward nor leeward shore. Here the strong winds are almost always Westerly, and whenever a Westerly gale springs up it finds already a heavy westerly swell running. This condition differs greatly from that of wind blowing over smooth water, for the air at once is compelled to follow an undulating course, and its principal effect is to increase the height of the existing swell.[1] Shorter waves are probably but little developed, their growth being hampered by the pre-existence of a longer aerial undulation. In a space of time, so short as to surprise those who are not accustomed to the conditions of these latitudes, the sea is running in great waves following one another in nearly perfect parallelism.

These waves soon attain the maximum height consistent with their speed and with the speed of the wind, and thereafter the principal change is a slow increase in their average length, and still slower increase in height. Thus at the end of a long-enduring storm in high southern latitudes, the waves are a few feet higher than those developed in the North Atlantic, but some hundreds of feet longer from crest to crest, and travelling with far greater speed. In the North Atlantic during a strong gale individual waves of 40 feet in height occur at short intervals, while in high southern latitudes the corresponding height of such ordinary maximum waves would probably be about 45 feet. But whereas in the North Atlantic under these conditions the average wave-length would not much exceed 400 feet, that in high southern latitudes would be somewhere about 700 feet.

Accompanying the conspicuous or dominant set of waves in a storm at sea there are not only the minor waves, the growth of which is (as has been said) hampered by the existence of longer steep waves, but also waves longer and flatter than the conspicuous or dominant set of waves, and these longer, flatter, and swifter waves we may group together and call the swell. I do not think it is correct to refer the whole of the swell which accompanies the storm-waves to former winds, stronger winds, or winds which have been blowing elsewhere. As far as my own obser-

[1] The downward pressure of the air is greatest where the horizontal velocity is least, and *vice versa*. Hence the air depresses the water in the troughs and sucks it up at the crests.

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vations go it has always seemed to me that the swell is getting up all the time the wind is blowing and that it is part of the work of the wind. If the wind had a sufficient length of fetch, *e.g.* were blowing in a straight line over 1000 miles of water, with a velocity of say 70 miles per hour, and if this wind-velocity were to continue for a sufficient time, say 100 hours at least, then the conspicuous or dominant set of waves would probably have a velocity of very nearly 70 miles per hour (and therefore a wave-length of about 2000 feet), but actual meteorological conditions differ so much from these specified above that the longest and swiftest waves compatible with the maximum velocity of the wind are never developed to their full extent, and the ideal condition of the steepest waves, being those with a velocity equal to that of the wind (as theoretically deduced by Stokes and by von Helmholtz) does not even approximately represent the actual facts at sea.[1] Nevertheless (on using the modern factor of reduction for converting Beaufort numbers to wind-velocities[2] in place of the older factor which gave excessive wind-velocities) I found that the maximum velocity of ocean *swells*, as obtained from the observation of their periodic time, does in fact agree pretty closely with the maximum velocity of wind, excluding the extreme speed only attained in gusts.

It seems probable, therefore, that all the time wind is blowing on deep water it is creating waves of all lengths up to that for which the wave-speed is equal to that of the wind. Whereas at first only the shortest have an appreciable steepness, and are therefore the conspicuous or dominant set of waves, yet as time goes on it is successively a longer and longer wave which becomes the conspicuous feature, and under actual conditions the waves which have a speed nearly or quite as great as that of the wind constitute an important part of the physical disturbance of the water, although they are not steep enough to be conspicuous during storms.

As an example of the very long waves formed during a storm, but chiefly seen afterwards, I may cite the following observations made by myself at Branksome Chine on the Dorset coast between Bournemouth and Poole, on December 29, 1898. The weather was fine after a heavy storm which accompanied a depression which had been traced from the other side of the Atlantic. Unusually heavy breakers began to arrive on the shore accompanied by a sound as of minute-guns. I timed them, and counted an *uninterrupted* series of 139 great breaking waves, the average period of which was 19·35 seconds, corresponding to a wave-length in deep water of 1918 feet, and a wave-velocity of 67·6 statute miles per hour.

When a storm ceases, and the wind no longer nurses the waves, the group of waves which it has created travels on under the action of gravity, with a velocity only equal to one-half that of the individual wave, the front wave of the group flattening out to nothing and its place being taken by a new one at the back of the group. The above group of swells, therefore, only advanced towards our shores at a speed of 38·8 statute miles per hour.

[1] With the moderate steepness of $\frac{\text{length}}{\text{height}} = 20$ a wave travelling 70 miles per hour would be 100 feet high.

[2] See *Quarterly Journal Roy. Met. Soc.* vol. 23, p. 25.

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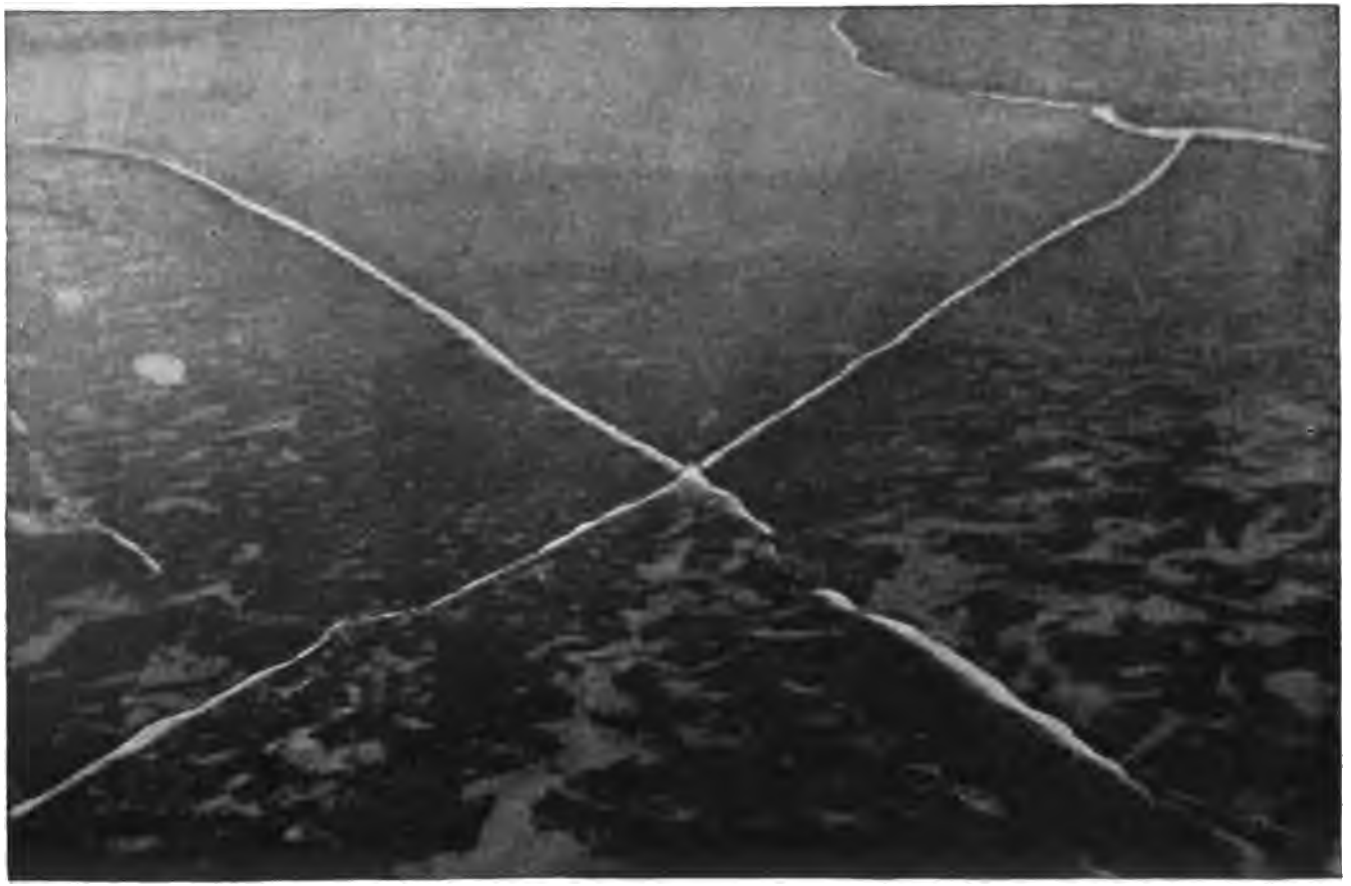


FIG. 1.—Two Waves crossing at nearly right angles in shallow water.

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This dual velocity—the wave-velocity and group-velocity—(worked out in detail by Osborne Reynolds [1]) is now a familiar notion. Equally important is it for the student of sea-waves to accustom himself to think of two atmospheric velocities, viz. (1) the rate of advance of a depression, and (2) the velocity of the wind generated therein. When a cyclonic or other depression advances towards our shores, the only part of it which is important from the wave-making point of view, is that in which the direction of the wind is the same as the direction of advance of the storm. Thus in a cyclone advancing from the west there is a position in the right-hand half, at a certain distance from the centre, where there is always a strong West wind. If the cyclone advance in a straight path great waves will traverse the ocean under this part of the depression.

But the cyclone may traverse the ocean slowly or swiftly, and the rate of its progress is not necessarily in any particular proportion to the violence of the wind generated in it. Now whereas observation shows that there is a fairly constant relation between height of wave and speed of wind—I find [2] that, on the average, height of the wave in feet is about half the velocity of the wind in statute miles per hour—there is much less regularity in the relation of velocity of wind to wave-length. Several reasons may be adduced as contributing to this, but I suggest that the above circumstance points to a reason of which sufficient account has not yet been taken. Thus a slow-moving cyclone will accompany slower-moving waves and the wind will nurse them, whilst the longer and swifter waves will run on ahead. The swifter-moving cyclone will accompany the longer and swifter waves, encouraging a longer sea. The maximum height of the waves will not differ greatly in the two cases and will depend mainly on the velocity of the wind, but in the first case there will be a shorter and steeper, in the second a longer and flatter sea.

Waves in Sand.

Various non-adhesive granular and powdery materials, such as sand and dry snow, fall into regular progressive waves when drifted by the wind. Larger gravel, although moving before the wind, does not form waves or ripples, and it would probably be possible to have a snowy powder so fine that it would not form any very definite or conspicuous waves. The physical constant which decides whether or not a non-adhesive granular material shall be a medium for surface-waves is the rate of subsidence of the granules. If this be as great as that of large gravel and small stones, the eddies of wind in the neighbourhood of inequalities are not of sufficient strength to lift the grains from the ground, or, if they be lifted, to hold them more than momentarily in suspension. If, on the other hand, the material be of extreme tenuity or lightness, it is caught up into the air by the upward movement of the slightest eddy, and remains there suspended as a cloud. In neither case are waves formed. In the earlier attempts to explain the rippling of sand by wind, one is familiar with the account given of the supposed way in which sand-grains, driven up the exposed weather-face of the ripple, roll down the lee cliff, the whole of the little hill thus advancing. I found by experiment with

[1] *Nature*, vol. **16**, 1877, p. 343. It was however noticed by J. Scott Russell in 1844.
[2] *Geographical Journal*, May 1904, "On the Dimensions of Deep-Sea Waves."

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sifted sand containing only grains so large as to be almost small gravel, driven by an artificial blast, that no vestige of rippling occurred, though the grains were rolled along smartly by the wind. In fact, a little consideration would enable one to foresee that as long as the sand-grains have only this mode of motion, the tendency would be for transverse inequalities to be obliterated instead of increasing, for the grains would tend to be driven from the exposed crests, and to accumulate in the sheltered hollows.

The best examples of æolian sand-waves which I have met with were produced in the river sand of the dried-up part of the Nile, in the low-water stage of that river, near Helwan, Egypt. The material is much finer and less rounded than ordinary seashore sand, but is nearly free from very minute and soft particles. When the wind blows briskly



Fig. 2.—Æolian Sand-Waves, near Helwan, Egypt, 1 ft. 6 in. high.

over this material, a slight haze of the finest particles rises to a height of twenty feet or so, remaining in suspension as long as the breeze endures. The greater part of the material, however, drifts in a different manner, of which the following is believed to be a fairly accurate account. The upward eddying movement acquired by the lowest layers of air (whose horizontal velocity is diminished) raises some of the sand into a state of "eddying suspension," and presently the lower layers of air become fully charged, so that thereafter they drop as much sand as they pick up, and there is, on the whole, neither silting nor scouring. But the equilibrium is extremely unstable, for whenever the air drops a little more than the exact overcharge (and some over-shooting of the mark is almost inevitable in the movement of ponderable bodies) it immediately becomes a scouring agent, picking up in the next succeeding section more than it drops. Thus, on the lee-side of the incipient ridge, formed by the excessive deposition, there is necessarily and consequently an incipient furrow formed. Thus inequalities necessarily originate; and, once originated, they are increased by the action of the eddies which they

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have produced, for there is a confluence of eddy-currents towards the tops of the ridges, and a separation or divergence of those currents from intermediate positions on the windward slopes of the ridges. Thus overloading of the air and consequent silting occurs at the crest, and a clarifying of the air followed by scouring action takes place at positions intermediate between the crests, so that the inequalities which, as I have explained, must of necessity originate, are thereafter increased by an equally necessary action. It must be observed, however, that those increasing inequalities are shifting their position down-wind all the time,

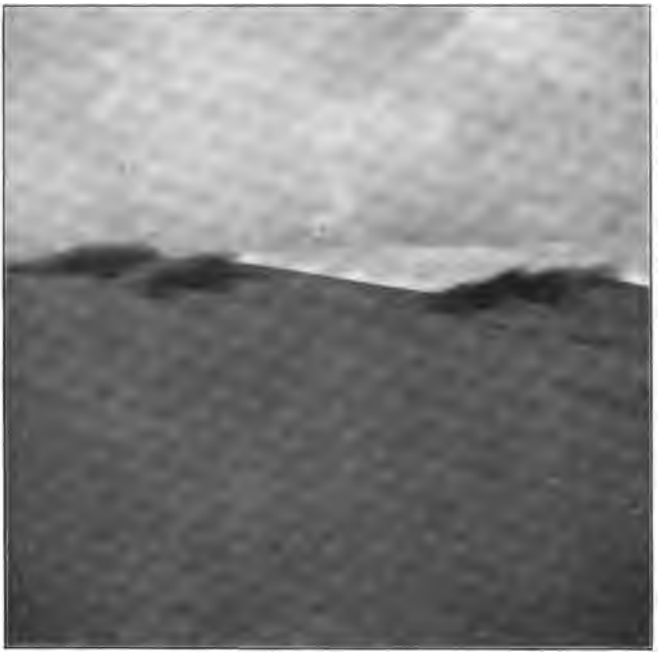


FIG. 3.—Æolian Sand-Ripples, near Southport.

the general drift of the sand causing the principal deposition to be always on the lee face of the crests. The excrescences, which originate in patches, rapidly coalesce in transverse ridges by the convergence of eddy-currents as viewed in a horizontal plane, which is similar to that already specified as occurring in a vertical plane. In the horizontal plane, however, gravity does not oppose the sand-drift to the extent which it does in a vertical sense, hence the lateral development of the ridges takes place much more rapidly than their vertical growth. The steepness of the sand-waves is limited by the resistance offered by a pile of the loose material to horizontal pressure. If one of the ridges were made too steep, a bodily sliding would occur, a part of the crest slipping into the trough. Hence the approximately constant ratio $\frac{\text{length}}{\text{height}} = 18$, which is found to hold for these æolian sand-waves.

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The height of the sand-waves is limited by the velocity of the wind. Thus when the wind drops to a gentle breeze the vortex or eddy on the lee of the high cliff is inadequate to the task of keeping the trough clear, and silting takes place there.

In the coarser quartz sand of the desert near the northern shore of the Peninsula of Sinai I have seen a series of great sand-dunes arranged as a train of waves, similar in appearance to those above described, but about one hundred times as large. I have not yet obtained measurements of groups of great transverse dunes, which are much to be desired, in order to see if the ratio of height to length is the same as for the smaller sand-waves.

When wind changes to the opposite quarter the tops of these great



FIG. 4.—Ripple-Mark of the Seashore, Montrose, Scotland.

dunes are turned, but it takes so considerable a time completely to reverse them that they quite commonly appear with reversed crest. The "setting" of the lower layers of large masses of sand, owing to the pressure of the superincumbent parts and other causes, renders the material no longer a homogeneous granular medium, and it no longer responds perfectly to the wave-making tendency of wind. Thus the study of great dunes is a mixed one, and would take us beyond the scope of this lecture.

On the other hand, there is a smallest kind of æolian sand-wave, which is properly termed a ripple, being purely a skin-deep wave, as is the capillary ripple formed in the "skin" of water. These little ripples, never more than a few inches from crest to crest, are a familiar feature on all exposed surfaces of loose dry sand upon coastal sand-dunes. Their ratio of length to height is the same as for the true sand-waves, viz. about 18, but that they are not merely small specimens of the same thing is shown by the fact that the said sand-waves are always tapestried

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over with a pattern of these ripples. The reverse does not, however, hold; for, although sand-dunes and sand-waves never occur unrippled, the ripples are continually formed when no larger waves are produced.

When experimenting with artificially sorted sandy materials and an artificial blast, I found, as already stated, that the largest kind of sand-grains of the kind sometimes called "lag gravel" did not of itself fall into ripples, but that when a handful of fine sand was scattered on its surface, rippling immediately appeared, and was very quickly increased and regularised. It appeared to me as I watched the process, that the eddies or vortices formed in the lee of the larger, lagging grains were of sufficient strength to pick up and for a time suspend the smaller grains; thus while the main conditions with regard to suspension, saturation, and eddies are not unlike those required for the formation of the æolian *waves*, the *ripples* require for their formation a moderate degree of heterogeneity in the granular material. It will be noticed in connection with this idea, that in a rippled surface of blown sand the material is much coarser on the crests than in the troughs. Usually the development of these ripples, as I have observed it on our coasts, takes place entirely during the gusts of wind, very little movement (or at any rate very little differential movement) taking place between the gusts even when the wind has the force of a "strong breeze."

Waves in Snow.

Snow freshly fallen, at such a temperature that the material is dry and not adhesive, falls at once into trains of travelling waves when drifted by the wind. When I have seen this happen in Canada the



Fig. 5.—Snow-Waves near Winnipeg.

temperature has been somewhere in the neighbourhood of zero Fahrenheit, or lower. The process is best observed where there is least inequality of ground and greatest uniformity of exposure; so wholly erroneous is what I may venture to call the common-sense view, with

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which most of us have started, that such waves need pre-existing inequalities to produce them. The fact which stands out so clearly from systematic as distinguished from casual observation is that the less the obstruction to free drifting the more quickly does local supercharge arise with its inevitable consequence of alternate silt and scour.

The waves produced by the drifting of freshly fallen snow are unrippled, a fact which supports the notion advanced above, that the æolian sand-ripples are due to the resistance of the larger grains, and the presence of smaller ones. The fresh-fallen snow is too friable to give the required resistances. When the snow has been turned over by the wind, the newly exposed surfaces are indeed carved into minor transverse



FIG. 6.—Rippled Cloud taken near Bournemouth.

ridges by the wind; but these are not true ripples in that they do not travel grain by grain. When, however, snow has, by melting and refreezing, attained an icy consistency, and the wind has broken the icy fragments into sand-sized granules, these form ripples a few inches from crest to crest, similar to those in sand, but flatter.

The ratio of length to height in travelling snow-waves I have found as great as 50, which shows how long and flat can be the eddy-space in which the horizontal velocity of wind is diminished.

Fifty to one is in round numbers a mile for every hundred feet, which suggests that a ridge of hill 500 ft. high affords effective wind-shelter for at least five miles. In order to do this its form must be fairly bold, for an outline like that of a gently rolling prairie would not give a strong eddy; but it need not be precipitous or anything approaching a precipitous form, for the snow-waves have a gently sloping back, and the lee face would, I think, seldom have a gradient of much more than 1 in 3.

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There need not, I think, be any hesitation in passing from the scale of inches to the scale of hundreds of feet, for the effect of the increased scale would be to heighten rather than diminish the action, owing to the fact that the air-current, which is felt as a wind on the ground, is of by no means indefinitely great thickness. In local winds especially, 500 ft. would be no negligible fraction of the whole depth of the air-current. The reasoning must not be applied without reserve, however, to the case of mountains thousands of feet high, for they may alter the whole system of atmospheric movement. I have commenced the application of this idea of wind-shelter in particular localities in England, and

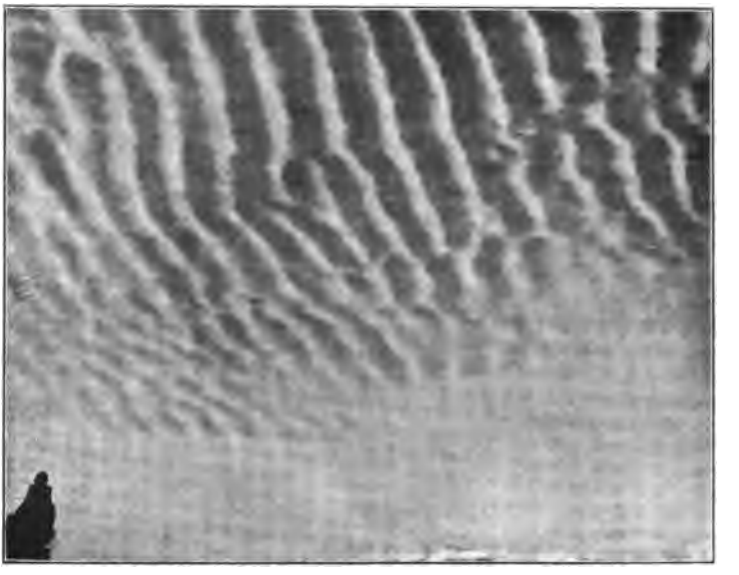


FIG. 7.—Negative of the Rippled Cloud photograph shown in the preceding Fig.

hope to publish something on the subject, when I have obtained more data.

WAVES IN CLOUDS.

When one stratum of air flows over another of greater density, the under surface of the former and the upper surface of the latter acquire an undulated form, and between the opposing crests of these two corrugated surfaces is a system of eddies or whirls which draw in air from both the upper and the lower stratum, sometimes with the result which so often happens on such admixture, viz. the precipitation of moisture as cloud. The broad clouds formed in these eddies are separated by narrow bands of blue sky, where are situated the opposing crests of the oppositely directed undulations of the relatively moving strata of air. The clouds form a mackerel sky, and it was of them that Ruskin said that they "fall into ripples like sand." The likeness is striking, but not carried out in

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detail, the ripple-mark of the seashore being sharp-ridged, whereas the clouds are rounded. The true aerial ripple-mark is, indeed, not the cloud pattern, but the pattern of the blue sky between the mackerel clouds. As the eye is dominated by the higher lights, this pattern is, however, not realised when viewing a mackerel sky or when looking at an ordinary photograph of such a sky. When, however, we examine the photographic negative, such as is here reproduced (Fig. 7), we see in the high lights, which correspond to the blue sky, the familiar sharp-ridged forms of sand rippled by sea-waves. The mackerel clouds correspond in fact to the swirling water which produces the ripple-mark, the blue sky to the inert sand-ridges which serve to keep the eddies distinct and apart.

Meteorological Charts of the Atlantic and Pacific Oceans.

Beginning with the month of July 1909, the U.S. Weather Bureau will publish Meteorological Charts of the North Atlantic and North Pacific Oceans monthly, and of the South Atlantic Ocean quarterly. It is proposed also to issue a seasonal chart of the South Pacific Ocean quarterly, from September next.

The Bureau receives reports from 2100 observers on vessels of every nationality, and from these reports prepares daily synoptic charts of the Meteorological data, being thus enabled to plot the meteorological conditions prevailing over the oceans from day to day, for the purpose of tracing storm-tracks, percentage of fog, prevailing direction of wind, trade-wind limits, pressure, and temperature. Mr. Henry L. Heiskell, the Chief of the Marine Division, states that it is the desire of the Chief of the Weather Bureau to popularise the charts, and to make them of benefit in a meteorological sense to those using them. With that end in view, he would therefore be pleased to receive any suggestions that would tend to their improvement.

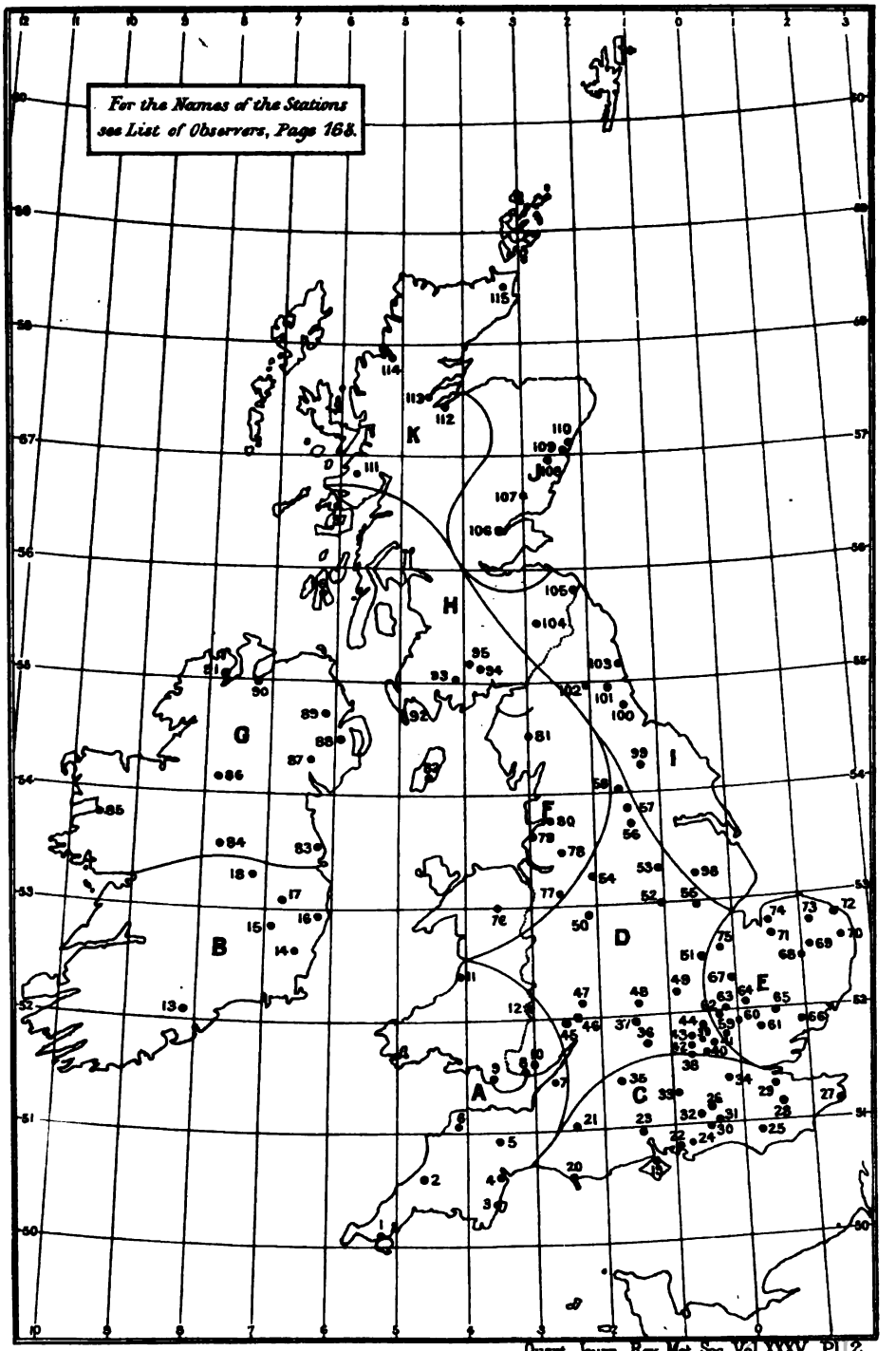
Local Authorities and Meteorological Instruments.

The provision of Meteorological Instruments by District Councils for recording local rainfall, amount of sunshine, temperature, etc., is one which is almost a necessity in health resorts and residential towns nowadays, for that town which can show the most hours of sunshine, and one or two of the south coast towns, by the way, seem, judging from the tall records furnished to the daily papers, to get a special sun all to themselves, is deemed to beat all other competitors. The question has, however, arisen in a number of cases as to whether expenditure in the purchase of such instruments would be legal, and would be passed by the auditors of the Local Government Board, for most towns which already possess such instruments have their own auditors, and their expenditure is not supervised by the Local Government Board. It appears that the Board have given a decision in favour of the legality of such expenditure on an appeal against a surcharge made by one of their auditors. "The Board do not consider," their communication runs, "that the auditor's decision in this case can be sustained. They are advised that instruments of this description are useful for the purpose of obtaining information as to influences likely to affect the public health, and they are consequently of opinion that the possession of those instruments enables the Medical Officer of Health to discharge with greater efficiency the duties pertaining to his office. This being so, the Board consider that it was competent to the District Council to provide the instruments for the use of the Medical Officer of Health at the cost of the funds under their control." —*Sanitary Record*, April 15, 1909.

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MAP SHOWING POSITION OF THE PHENOLOGICAL STATIONS, 1908.



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REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1908.

By EDWARD MAWLEY, F.R.Met.Soc., V.M.H.

(Plate 2.)

[Read February 17, 1909.]

THE following changes have taken place in the observing stations since the last Report was issued. No returns were received during the year from Skibbereen in District **B**; Ditton Hill in District **C**; Broxbourne in District **E**; and Doddington in District **I**. On the other hand, new stations have been started, or old ones revived, at Kilcullen in District **B**; Hellingly in District **C**; Chadlington in District **D**; Roxton in District **E**; Bowdon and Birkdale (Southport) in District **F**; Salen in District **H**; and Lincoln, Burnopfield, Blyth, and Galashiels in District **I**. The total number of observing stations is now 116.

TABLE I.—MEAN RESULTS, WITH THEIR VARIATIONS FROM THE 18 YEARS' AVERAGE (1891-1908), FOR THE THIRTEEN PLANTS IN THOSE DISTRICTS WHERE THERE HAVE BEEN SUFFICIENT OBSERVATIONS TO WARRANT COMPARISONS BEING MADE.

YEARS.	Eng. S.W.		Eng. S.		Eng. Mid.		Eng. E.		Eng. N.W.	
	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.
		Days.		Days.		Days.		Days.		Days.
1891	144	+ 9	144	+ 8	150	+10	147	+10	150	+ 6
1892*	139	+ 4	138	+ 2	144	+ 4	143	+ 6	147	+ 3
1893	118	- 17	122	- 14	125	- 15	123	- 14	128	- 16
1894	126	- 9	130	- 6	135	- 5	127	- 10	137	- 7
1895	139	+ 4	138	+ 2	141	+ 1	138	+ 1	144	0
1896*	125	- 10	128	- 8	132	- 8	130	- 7	134	- 10
1897	130	- 5	132	- 4	136	- 4	132	- 5	142	- 2
1898	133	- 2	135	- 1	138	- 2	136	- 1	141	- 3
1899	136	+ 1	136	0	141	+ 1	138	+ 1	145	+ 1
1900	142	+ 7	141	+ 5	144	+ 4	143	+ 6	152	+ 8
1901	138	+ 3	139	+ 3	141	+ 1	139	+ 2	144	0
1902	139	+ 4	140	+ 4	145	+ 5	142	+ 5	152	+ 8
1903	134	- 1	134	- 2	137	- 3	134	- 3	145	+ 1
1904*	139	+ 4	139	+ 3	142	+ 2	140	+ 3	149	+ 5
1905	133	- 2	135	- 1	138	- 2	136	- 1	144	0
1906	135	0	134	- 2	138	- 2	137	0	143	- 1
1907	142	+ 7	139	+ 3	143	+ 3	142	+ 5	149	+ 5
1908*	139	+ 4	138	+ 2	142	+ 2	142	+ 5	148	+ 4
Mean	135	...	136	...	140	...	137	...	144	...

Explanation of the Dates in the Tables.

1- 31	are in	January.	183-213	are in	July.
32- 60	,,	February.	214-244	,,	August.
61- 91	,,	March.	245-274	,,	September.
92-121	,,	April.	275-305	,,	October.
122-152	,,	May.	306-335	,,	November.
153-182	,,	June.	336-366	,,	December.

* Leap years.

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The averages, with which the mean dates of the different plants are compared in Table IV., have been obtained from the actual observations made during the 18 years 1891-1908 in all those districts where sufficient observations were obtainable. Those for the two remaining districts are as near approximations to the true averages as the limited number of records will allow.

The Winter of 1907-8.

This was on the whole a mild winter, December and February being unseasonably warm, and January about as unseasonably cold. The first month of the quarter proved wet, and January dry, while the rainfall in February was about average. January was sunny for a winter month, but in December and February the record of bright sunshine in most districts fell short of the average.

The sowing of winter corn, which had been greatly interrupted by the heavy rains which fell in the latter half of November, was brought to a close by a still wetter period in the early part of December. During January the conditions were, on the whole, favourable for the preparation of the land for the spring cereals, as the severe frosts at the beginning of that month served to pulverize the ground and render it more workable. So that those farmers who were able to take advantage of the continuance of those favourable conditions during the first two weeks in February, planted their spring corn in an excellent seed-bed. After that time, however, owing to the frequent falls of rain, the progress made was neither as rapid nor as good. The autumn-sown cereals, as in the previous winter, came up slowly, but on the whole presented a fairly promising appearance at the end of the season, notwithstanding the trying period they had passed through during the severe frosts in the early part of January. The root and hay crops of the previous year had been so good that there was never any lack of fodder for the cattle and sheep during the whole winter.

In Scotland the work of ploughing the land for the reception of corn was very backward at the beginning of the winter, but great progress was made towards making up arrears during the drier weather in February.

The weather remained so mild until nearly the end of December, that many wild and garden plants were here and there to be seen still in flower throughout the whole of the southern half of England, and in some cases in the more northern counties. The winter supply of green vegetables was well maintained until the January frosts, which did much damage to the less hardy kinds. This was, on the whole, a favourable winter for all seasonable garden work, and more especially was this the case during the dry period in February, when the transplanting of trees, shrubs, etc., could be carried out under the most favourable conditions, both of soil and weather.

The fertile flowers on the hazel, taking the country as a whole, made their appearance 3 days earlier than usual.

The song-thrush was first heard after the beginning of January, 1 day late.

The honey-bee was first seen to visit flowers 7 days late.

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The Spring.

A cold, wet, and sunless quarter. The first two months of this important season, as regards the cultivation of the land for the reception of farm and garden seeds, were very cold, while rain fell not only in excess of the average, but also with unusual frequency. In most districts there was a marked deficiency of sunshine in all three months.

This proved a trying season for the farmers, and especially for those who missed the very favourable period in February before referred to. For only now and again afterwards could suitable conditions be found for getting in spring corn, owing to the frequent falls of rain in March and April, and even when short intervals of better weather came the ground had by that time become hard and difficult to work. So that the corn planted during this spring seldom found an altogether satisfactory seed-bed, and had in some cases to be ploughed up and re-sown. During the drier and warmer weather in May better progress was made. It is seldom that so much corn has had to be sown so late as May. In fact, a good deal had to remain unsown until June. The autumn-sown cereals during the greater part of the season were backward and thin. The warmer weather in May, however, hastened their growth and improved their colour. It also served to bring on the spring corn, and particularly that which had been planted early. The irregularity of the growth was no doubt due to two causes, at first the rotting of the grain in the ground, owing to a cold, wet, and rough seed-bed, and afterwards the exceptionally severe attacks of wire-worms and grubs. Little if any injury appears to have been done by the heavy falls of snow and low temperatures towards the end of April. The meadows and pastures remained unusually bare during March and April, but the warm rains in May soon caused the grass to spring into active growth, so that at the end of the season there was every promise of an abundant crop of hay.

In the gardens the early sown seeds, owing to the coldness of the soil, germinated slowly and irregularly, while, on the other hand, those put in during May came up quickly and regularly. The keen frosts and heavy fall of snow which occurred towards the end of April did much damage in many places to the more tender shrubs, and also to the fruit blossom and early potatoes.

Many of the Society's observers refer to the injuries done to timber and other trees and shrubs by the weight of the snow, during the same April snowstorm, breaking off their branches, and in some cases uprooting the trees themselves. This exceptionally heavy fall of snow for the time of year appears to have been general all over the country, although less deep in the colder parts of the British Isles than in the southern half of England. Mention is also made of young birds perishing through their nests becoming filled with snow. Another remarkable feature of this spring was the surprising growth made by vegetation generally after the few hot days at the beginning of May, as is invariably the case when unusually warm weather sets in after a long spell of cold. So marked was the change that it almost immediately transformed the appearance of the landscape.

All the spring plants on the list, except the coltsfoot, which was 1 day early, flowered later than usual, the wood anemone being 3 days late,

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the blackthorn 13 days late, the garlic hedge-mustard 6 days late, the horse-chestnut 10 days late, and the hawthorn 9 days late.

Of the spring migrants included in the report the swallow was 8 days late, the cuckoo 6 days late, and the nightingale 9 days late—all three making their appearance later than in any year since the present

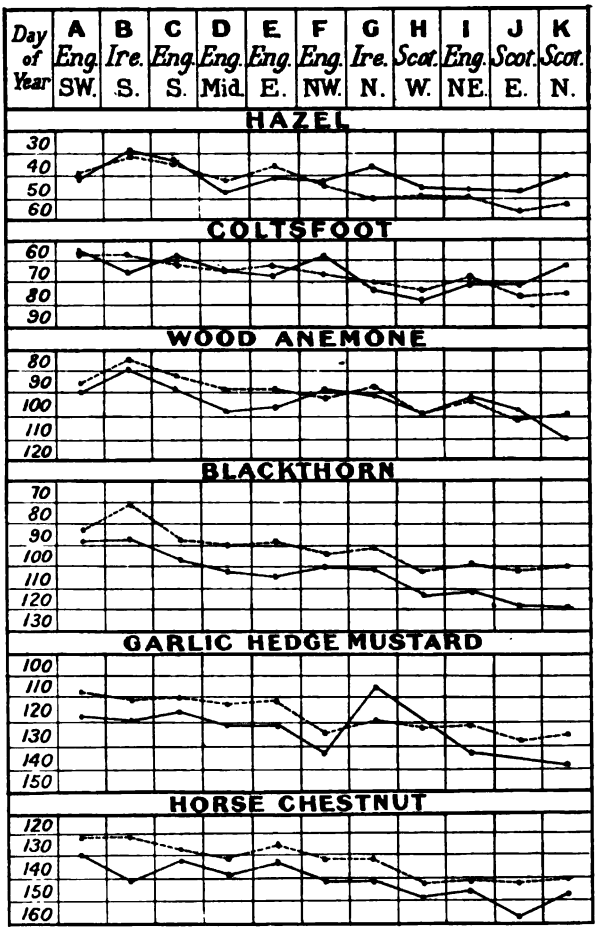


FIG. 1.

system of observation was adopted 18 years ago. The flycatcher, on the other hand, was 1 day early.

The wasp first appeared 9 days late, the small white butterfly 9 days late, and the orange-tip butterfly 11 days late.

The Summer.

Regarded as a whole, this was a dry and bright summer of about average temperature. June and August were in most parts of the

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country more or less cold, whereas in July the mean temperature was generally above the average. In all three months the fall of rain was in most districts deficient, and there occurred an unusual number of dry days, while the duration of bright sunshine was in excess of the mean.

The corn crops, favoured by the warm weather in May and the early

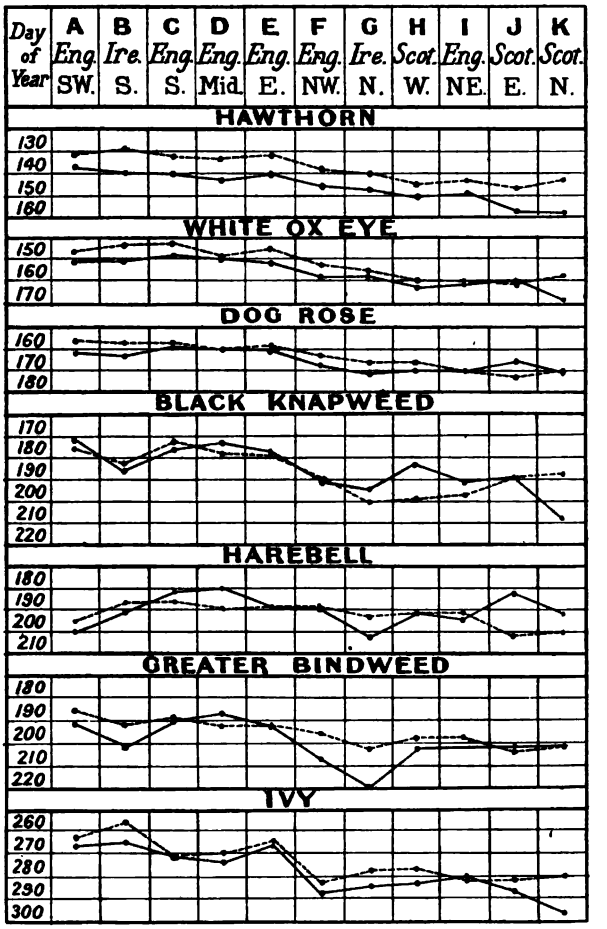


FIG. 2.

part of June, greatly improved, and there appeared every prospect of at all events a moderately good yield—which, earlier in the year, had appeared almost impossible. Of the cereal crops the one most benefited by the changed conditions of weather was that of wheat. The dry weather between the middle of May and the middle of June rather checked the further growth of the grass, which, although an excellent crop, was not as heavy as it at one time promised to be. It was, however, harvested in excellent condition, and with little trouble or

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expense. The dry weather continued so long that before the end of June the pastures were becoming parched, while fears were entertained as to the autumn-sown oats and spring corn, the straw of which was very short. The roots also from the same cause made no progress. With the advent of July came most opportunely a return to wet weather, light rain falling almost every day during the first three weeks of that month, which enabled all the crops to start again into fresh growth. The roots and grass grew rapidly, and the ears of corn began to swell. After the third week of this moderately wet period dry weather again set in, which lasted over four weeks, and allowed the belated hay in the colder districts to be got in, while it also permitted, at all events in the warmer parts of the country, nearly the whole of the corn to be secured in admirable condition, and under circumstances equally as favourable as the hay crop earlier in the season. Fortunately for all the other farm crops except the cereals, the last ten days in August proved wet. The frequent rainfall of that period prevented the completion of the harvest in the southern counties, and caused a good deal of corn, which had been already cut, in the colder districts of these Islands to remain for a week or ten days exposed in the fields. On the other hand, the roots and pastures were greatly benefited by the change to moister weather. On the whole, somewhat similar conditions prevailed in the north of England and in Scotland. The hay being in most cases well harvested, the first drought dwarfed the corn, while the second drought caused the pastures to become dry and bare, and arrested the growth of the root crops.

The moderate temperatures of this season favoured the welfare of most garden plants, the only drawbacks being the two dry periods before mentioned. The most trying of these was that lasting from the middle of July to the middle of August. Fortunately, the weather during the latter half of that period continued cool, so that this drought was not as keenly felt as it otherwise might have been.

All the summer-flowering plants on the list, except the harebell, which was 3 days early, and the black knapweed, which flowered at its average date, came into blossom behind their usual dates, the white ox-eye being 4 days late, the dog-rose 2 days late, and the greater bindweed 4 days late.

The meadow brown butterfly made its appearance 7 days later than usual.

The Autumn.

The three autumn months were all warm, and October exceptionally so—the departure from the average temperature in that month ranging between $+4°{\cdot}3$ in the south of England to $+6°{\cdot}4$ in the north of Scotland. The rainfall in September was in most districts in excess of the average, but in the other two months there was a marked deficiency. The records of bright sunshine were extremely variable, but generally much better in the southern than in the northern half of the British Isles.

In the northern counties, as well as in some of those farther south, a good deal of the corn was stained or otherwise injured by the wet weather at the end of August and beginning of September, and particularly was this the case in the north of Ireland and Scotland, where much corn was

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stacked in a very unsatisfactory condition. The experiences of farmers in the moderately late districts appears to have varied greatly, some stating that their corn escaped without injury, others with but little injury, while in other cases the crops were stated to be much damaged. The roots greatly improved and made splendid growth, especially in the exceptionally warm period of the first three weeks in October. Unlike the two previous autumns, the autumn of 1908 proved extremely favourable for working the land, and planting the winter cereals, which were nearly everywhere got in with little labour and under the best possible conditions, the ground being, as a rule, just moist enough without being too wet. Even in Scotland most of the corn had been planted before the end of November. The grass revived and continued unusually abundant and fresh throughout the rest of the season. The newly-planted corn, favoured by the warmth of the ground, germinated quickly.

As had been the case in the fields, this proved a remarkably favourable autumn both in the flower and kitchen garden. So that in the former, all but the most tender plants remained in a growing and flowering condition throughout the season. Good growth was also made in the kitchen garden—in fact, in the case of the green vegetables too much growth, should the coming winter bring with it anything like severe frosts. The crop of apples was in several districts a good one, but owing to unusually warm and dry weather following a period of wet, the great rush of sap in the trees caused a good deal of the fruit to fall prematurely.

The luxuriance of the foliage on timber and other trees during the summer and autumn was very noticeable. Moreover, while the leaves remained on the trees to an unusually late date, the fall of the leaf was rather rapid when it once began. The autumn tints in many places are reported to have been remarkably fine while they lasted. The number of instances of fruit and other trees flowering again a second time was during this autumn unusually large. Blackberries were very abundant, but there were in most places but few holly berries.

The only autumn plant on the list, the ivy, came into flower 6 days later than its average date.

Taking the country as a whole, the last swallow took its departure 4 days earlier than its usual time.

According to the *Preliminary Statement* for Great Britain, issued by the Board of Agriculture, the yield of wheat per acre exceeded the average for the previous 10 years by 0·59 bushel, oats by 0·05 bushel, beans by 0·10 bushel, peas by 0·92 bushel, while barley fell short of the average by 0·57 bushel. Turnips and swedes exceeded the average by 2·15 tons, mangolds by 1·73 tons, and potatoes by 1·19 tons, hay (permanent pasture) by 0·90 cwt., and hay (clover, etc.) by 1·47 cwts. per acre. The crop of turnips and swedes, and also that of potatoes, was heavier than in any year since official statistics were first collected in 1884, while that of mangolds was the heaviest during the same period, with the exception of 1902.

Taking the country as a whole the rainfall of the autumn of 1907 was below the average, while the yield of wheat in 1908 was above the average. This serves to bear out Dr. Shaw's contention, as it has often done before, that a small rainfall in the autumn of one year is almost

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TABLE II.—List of the Stations with the Names of the Observers.

Station.	County.	Height above Sea-level.	Observer.
A		Ft.	
1. Mawnan	Cornwall	...	Captain A. Rogers, R.N.R.
2. Altarnon	Cornwall	600	C. U. Tripp, M.A.
3. Brixham	Devon	40	F. W. Millett.
4. Starcross	Devon	50	P. G. Waterfield.
5. Tiverton	Devon	270	Miss M. E. Gill.
6. Barnstaple	Devon	90	T. Wainwright.
7. Clifton	Gloucester	300	G. C. Griffiths, F.E.S.
8. Penarth	Glamorgan	120	G. A. Birkenhead.
9. Bridgend	Glamorgan	90	H. J. Randall, Junr.
10. Little Mill	Monmouth	300	W. J. Grant, F.R.H.S.
11. Aberystwyth	Cardigan	30	J. H. Salter, D.Sc.
12. Whitney-on-Wye.	Hereford	430	W. Burgess.
B			
13. Tallow	Waterford	...	Mrs. H. C. Deane.
14. Ferns	Wexford	260	G. E. J. Greene, M.A., D.Sc.
15. Bagenalstown	Carlow	290	Miss F. S. Wynne.
16. Ovoca	Wicklow	110	Miss W. F. Wynne.
17. Kilcullen	Kildare	500	V. de C. Hughes.
18. Geashill	King's County	280	Rev. Canon Russell.
C			
19. Bembridge	Isle of Wight	80	C. Orchard, F.R.H.S.
20. Weymouth	Dorset	100	N. M. Richardson.
21. Buckhorn Weston	Dorset	290	Miss H. K. H. D'Aeth.
22. Havant	Hants	30	H. Beeston.
23. Botley	Hants	30	Lady Jenkyns.
24. Birdham	Sussex	10	A. J. Nixon.
25. Hellingly	Sussex	170	M. Stroud.
26. Muntham	Sussex	250	P. S. Godman, F.Z.S.
27. Dover	Kent	150	F. D. Campbell.
28. Staplehurst	Kent	110	Rev. J. S. Chamberlain.
29. Maidstone	Kent	100	Mrs. Silcock.
30. Chiddingfold	Surrey	230	Mrs. Maclear.
31. Cranleigh	Surrey	180	Miss H. E. Ravenscroft.
32. Coneyhurst	Surrey	600	J. Russell.
33. Churt	Surrey	350	Rev. A. W. Watson.
34. Purley	Surrey	350	J. E. Clark, F.R.Met.Soc.
35. Marlborough	Wilts	480	E. Meyrick, F.R.S.
D			
36. Oxford	Oxford	200	F. A. Bellamy, M.A., F.R.A.S.
37. Chadlington	Oxford	400	Miss M. S. A. Burlton.
38. Harefield	Middlesex	340	G. E. Eland.
39. Chesham	Bucks	300	Miss G. Keating.
40. Watford	Herts	270	Mrs. J. Hopkinson.
41. St. Albans (New Green's Farm)	Herts	400	Miss A. Dickinson.
41. St. Albans (Glenferrie Road)	Herts	320	W. P. Westell, F.R.H.S.
42. King's Langley	Herts	400	M. Arnold.
43. Berkhamsted	Herts	400	Mrs. E. Mawley.
44. Harpenden	Herts	370	J. J. Willis.
45. Ross	Hereford	210	H. Southall, F.R.Met.Soc.
46. Dymock	Gloucester	120	Miss M. Peake.
47. West Malvern	Worcester	600	Mrs. Kensington.
48. Farnborough	Warwick	520	Miss D. J. G. Prater.

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TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
49. Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
50. Stone	Stafford	330	W. Wells Bladen.
51. Ketton	Rutland	290	Rev. A. H. Snowden.
52. Beeston	Notts	210	G. Fellows.
53. Hodsock	Notts	60	Miss Mellish, F.R.H.S.
54. Macclesfield	Cheshire	500	J. Dale.
55. Belton	Lincoln	200	Miss F. H. Woolward.
56. Altofts	Yorks (W.R.)	120	H. G. Townsend.
57. Horbury	Yorks (W.R.)	210	W. Rushforth.
58. Ripley	Yorks (W.R.)	240	Rev. W. T. Travis.
E			
59. Hatfield	Herts	380	Miss R. Blackett.
60. Hertford	Herts	140	W. Graveson.
61. Sawbridgeworth	Herts	350	H. S. Rivers.
62. Hitchin	Herts	220	A. W. Dawson, M.A.
63. Odsey (Ashwell)	Cambridge	260	Sir H. G. Fordham.
64. Shelford	Cambridge	60	C. E. Smith.
65. Bocking	Essex	240	H. S. Tabor, F.R.Met.Soc.
66. Lexden	Essex	90	S. F. Hurnard.
67. Boxton	Beds	...	Miss G. H. Day.
68. Carleton-Forehoe	Norfolk	100	Rev. C. H. Master.
69. Tacolneston	Norfolk	190	Miss E. J. Barrow.
70. Eaton (Norwich)	Norfolk	100	A. W. Preston, F.R.Met.Soc.
71. Southacre	Norfolk	100	Rev. E. T. Daubeney.
72. Brunstead	Norfolk	30	Rev. M. C. H. Bird.
73. Hevingham	Norfolk	...	Major Marsham.
74. Clenchwarton	Norfolk	10	Miss E. M. Stevenson.
75. Peterborough	Northampton	30	J. W. Bodger.
F			
76. Llangollen	Merioneth	270	T. Ruddy.
77. Betley	Stafford	250	Miss M. L. Hodgson.
78. Bowdon	Cheshire	150	T. A. Coward.
79. Birkdale (Southport)	Lancashire	220	J. F. Knowlson.
80. Preston	Lancashire	50	J. R. Charnley, F.G.S., F.Z.S.
81. Ambleside	Westmoreland	220	Miss Drury.
82. Cronkbourne	Isle of Man	110	A. W. Moore and J. Murphy.
G			
83. Ardgillan	Dublin	210	J. Woodward.
84. Edgeworthstown	Longford	270	J. M. Wilson, M.A.
85. Westport	Mayo	10	J. M. McBride.
86. Chanter Hill	Fermanagh	250	The Dean of Clogher.
87. Loughbrickland	Down	350	Rev. Canon Lett.
88. Saintfield	Down	310	Rev. C. H. Waddell, M.A.
89. Antrim	Antrim	70	Rev. W. S. Smith.
90. Altnafoyle	Londonderry	450	T. Gibson.
91. Milford	Donegal	150	Miss Osborne.
H			
92. Kirkmaiden	Wigtown	100	Rev. D. R. Williamson.
93. New Galloway	Kirkcudbright	450	T. R. Bruce.
94. Jardington	Dumfries	100	J. Rutherford.
95. Moniaive	Dumfries	350	J. Corrie.
96. Port Ellen	Isle of Islay	10	T. F. Gilmour.
97. Salen	Argyll	60	Miss R. M'Naughten.

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TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
I			
98. Lincoln	Lincoln	200	Rev. F. L. Blathwayt.
99. Thirsk	Yorks (N.R.)	120	A. B. Hall.
100. Durham	Durham	350	Prof. R. A. Sampson and F. C. H. Carpenter.
101. Burnopfield	Durham	580	H. F. Bulman.
102. Corbridge-on-Tyne	Northumberland	200	A. W. Price.
103. Blyth	Northumberland	20	S. Dunnett.
104. Galashiels	Selkirk	460	H. Sanderson.
105. West Foulden	Berwick	250	J. H. Craw.
J			
106. Forgandenny	Perth	...	D. Nicoll.
107. Kirriemuir	Forfar	250	T. M. Nicoll.
108. Durris	Kincardine	420	A. Macdonald, M.A.
109. Crathes	Kincardine	140	J. Smith, F.R.Met.Soc.
110. Aberdeen	Aberdeen	40	P. Harper.
K			
111. Invermoidart	Inverness	60	S. M. Macvicar.
112. Beauly	Inverness	60	A. Birnie.
113. Dingwall	Ross	10	J. P. Smith, M.D.
114. Inverbroom	Ross	50	Lady Fowler.
115. Watten	Caithness	150	Rev. D. Lillie.

The numbers before the names of the stations refer to their position on the Map of the Stations. (Plate 2.)

invariably followed by a good crop of wheat in the next year, although, as will have been gathered from the foregoing description of the state of the wheat crop in the early spring, the intervention of the weather in May at a critical period of its growth must also have had considerable influence in bringing about the required result.

The yield of fruit was variable, but, taking the country as a whole, rather poor. Apples in the south-western, southern, and midland counties of England were a good crop, but throughout the rest of the British Isles below average, while pears and plums were everywhere very deficient. On the other hand, all the small fruits, such as raspberries, currants, gooseberries, and strawberries, were excellent crops.

The Year.

The most noteworthy features of the weather of the phenological year ending November 1908 were the severe frosts early in January, the exceptionally heavy fall of snow and remarkably low temperatures in the latter part of April, and the marked periods of unusually wet and unusually dry weather during the summer. In February and March wild plants came into blossom in advance of their usual time, but throughout the rest of the flowering season were more or less behind their average dates. Such early spring migrants as the swallow, cuckoo, and

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TABLE III.—Date (Day of Year) of First Flowering of Plants, 1908.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
A													
Mawnan . .	49	...	89	90	...	133	126	136	165	176	...	193	...
Altarnon . .	58	80	120	122	138	142	154	175	176	193	213	216	262
Brixham . .	36	40	...	88	...	130	141	...	...	...	...	200	269
Starcross . .	34	52	...	93	123	122	122	152	148	153	...	174	259
Tiverton . .	51	49	90	79	112	133	122	151	160	165	...	...	280
Barnstaple . .	25	59	82	94	110	122	137	162	163	178	218	190	269
Clifton . .	...	...	...	...	...	132	141	...	...	...	...	...	...
Bridgend . .	51	65	91	108	123	138	147	154	164	170	188	198	270
Little Mill . .	34	60	77	112	101	118	134	130	153	171	...	163	251
Aberystwyth .	45	53	89	90	106	135	141	146	161	167	187	184	256
Whitney-on-Wye .	42	35	81	108	...	...	143	150	157	179	196	204	284
B													
Tallow . .	19	61	77	95	...	128	133	151	...	197	...	193	...
Ferns . . .	39	81	*103*	77	...	*99*	142	151	163	*210*	*233*	204	265
Bagenalstown .	...	68	...	101	...	141	142	...	...	...	...	...	...
Ovoca . . .	16	...	...	97	...	148	141	150	...	192	...	...	...
Kilcullen . .	...	*88*	...	112	...	140	139	153	164	177	...	...	...
Geashill . .	42	53	82	102	119	147	141	151	166	177	...	205	...
C													
Bembridge . .	31	22	88	102	121	121	128	132	163	...	...	...	...
Weymouth . .	40	...	95	101	...	...	138	159	169	168	...	181	275
Buckhorn Weston	39	74	73	114	114	135	139	149	161	162	...	186	262
Havant . .	26	...	88	108	108	131	141	141	158	...	182	185	272
Botley . .	37	73	92	86	111	136	138	149	161	186	...	200	274
Birdham . .	36	67	...	75	112	...	*125*	...	153	170	...	...	...
Hellingly . .	*72*	77	91	122	105	138	141	143	155	...	...	...	...
Muntham . .	40	41	83	109	109	128	133	147	157	180	...	193	266
Dover . . .	...	67	...	99	...	132	141	...	169	181	...	...	270
Staplehurst . .	32	55	84	114	104	125	131	137	153	175	175	183	...
Maidstone . .	16	48	84	116	111	132	136	146	153	169	...	179	261
Chiddingfold .	43	...	77	106	...	136	150	150	153	177	...	201	*325*
Cranleigh . .	37	...	...	107	123	131	145	143	157	181	...	...	...
Coneyhurst . .	40	*109*	97	120	...	131	143	161	166	183	175	192	280
Churt . . .	32	49	90	115	123	136	145	149	155	171	183	198	...
Purley . .	40	38	94	118	128	135	144	146	162	*203*	194	...	280
Marlborough .	26	68	87	95	121	137	142	148	163	176	186	188	...
D													
Oxford . .	...	...	...	...	110	133	133	132	157	...	192	...	266
Chadlington .	*71*	79	94	109	113	...	141	143	154	177	186	186	...
Harefield . .	...	...	89	123	126	134	141	150	160	176	*213*	196	...
Chesham . .	53	67	92	120	122	137	143	...	157	...	...	...	...
Watford . .	35	69	...	101	107	133	140	145	158	166	178	170	268
St. Albans (New Greens Farm)	43	...	92	108	122	131	145	151	157	174	174	...	268
St. Albans (Glenferrie Road)	...	68	108	123	123	137	145	151	157	192	185	208	284
King's Langley .	*67*	...	...	113	115	139	149	151	162	...	...	...	...
Berkhamsted .	50	55	105	122	125	139	155	148	155	183	189	191	...
Harpenden . .	54	80	99	115	117	137	144	149	159	167	...	...	...
Ross . . .	33	54	88	100	105	132	130	...	157	166	...	...	283

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TABLE III.—Date (Day of Year) of First Flowering of Plants, 1908—*continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
Dymock . .	44	51	82	102	110	137	138	142	157	160	...	164	...
West Malvern .	55	39	87	106	111	135	140	162	154	161	179	182	293
Farnborough .	39	42	106	113	123	139	138	145	155	*202*	*213*	...	269
Northampton .	46	65	87	107	126	140	144	150	162	176	184	193	258
Stone . . .	...	78	...	...	...	143	148	...	...	...	...	209	...
Ketton . .	...	...	...	...	...	141	141	...	159	...	...	...	...
Beeston . .	*68*	...	...	125	134	...	...	160	166	179	151	...	...
Hodsock . .	50	70	95	110	125	136	141	155	168	189	186	187	...
Macclesfield .	60	87	121	118	141	148	151	163	173	184	186	191	275
Belton . .	43	83	90	125	128	132	141	156	160	169	179	183	...
Altofts . .	*65*	75	98	*137*	122	144	151	...	173	155	163	173	...
Horbury . .	...	37	98	...	...	...	...	...	...	...	189	189	...
Ripley . .	...	76	92	...	137	143	150	154	...	...	...	...	...
E													
Hatfield . .	41	...	92	100	...	131	...	144	155	...	203	...	...
Hertford . .	42	61	86	103	111	134	135	147	159	163	185	194	281
Sawbridgeworth .	44	67	...	...	...	...	...	...	161	...	...	...	...
Hitchin . .	37	75	89	107	119	134	138	152	158	...	...	...	...
Odsey (Ashwell) .	38	...	...	112	...	...	145	...	...	...	...	...	270
Shelford . .	41	69	*128*	125	129	133	140	142	156	...	199	...	268
Bocking . .	42	68	106	120	120	135	140	152	157	178	193	201	270
Lexden . .	54	...	103	120	...	132	137	...	160	171	182	...	267
Roxton . .	32	50	66	109	...	133	...	...	...	...	...	...	...
Carleton-Forehoe .	47	74	117	127	122	139	...	*166*	169	...	...	...	273
Tacolneston .	40	68	112	124	113	...	142	155	...	...	...	...	...
Eaton (Norwich) .	*65*	...	98	131	128	133	141	153	163	...	...	187	250
Southacre . .	...	72	80	105	122	133	141	159	162	171	178	...	264
Brunstead . .	37	74	...	119	124	136	144	153	159	195	188	208	271
Hevingham . .	...	...	86	...	...	...	142	...	...	...	...	...	...
Clenchwarton .	...	*27*	...	...	...	138	141	...	158	*210*	...	184	268
Peterborough .	33	71	109	110	119	135	136	151	158	182	187	193	260
F													
Llangollen . .	39	49	*107*	104	120	140	142	151	167	196	199	204	284
Betley . . .	45	...	87	116	*148*	140	143	164	167	187	193	205	292
Bowdon . .	...	67	91	108	137	138	149	157	170	202	189	208	291
Birkdale (Southport)	...	...	...	...	141	135	143	...	...	...	...	...	...
Preston . .	...	63	...	...	...	...	...	...	...	...	...	...	...
Ambleside . .	35	56	...	111	132	145	152	159	162	181	181	212	284
Cronkbourne .	51	58	...	...	135	146	147	160	...	...	*237*	204	290
G													
Ardgillan . .	39	67	95	107	...	142	145	153	176	210	210	223	302
Edgeworthstown .	...	...	...	99	...	*155*	155	...	167	...	...	...	...
Westport . .	35	...	...	115	...	149	144	...	...	...	...	...	266
Chanter Hill .	37	61	90	99	105	134	146	156	169	185	194	209	283
Loughbrickland .	*69*	91	*106*	123	...	123	147	*170*	173	204	...	231	299
Saintfield . .	...	...	83	106	...	140	147	162	171	...	...	...	282
Antrim . .	52	...	...	...	...	145	144	...	168	190	...	213	...
Altnafoyle . .	46	72	...	125	...	150	149	...	174	194	...	...	...
Milford . .	7	...	...	...	...	145	147	156	...	189	...	224	280

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TABLE III.—Date (Day of Year) of First Flowering of Plants, 1908—*continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
H													
Kirkmaiden. .	52	48	96	122	...	151	155	170	174	...	*212*	202	273
New Galloway .	38	96	108	131	...	...	155	175	173	202	196	...	...
Jardington . .	45	95	93	122	...	150	148	159	171	167	191	...	...
Moniaive . .	...	...	100	135	...	*159*	156	159	162	...	187	204	*310*
Port Ellen . .	*75*	72	...	111	...	145	144	...	172	...	...	...	...
Salen . . .	...	...	...	...	*160*	150	151	157	169	...	...	...	295
I													
Lincoln . .	40	93	96	...	131	139	143	157	157	...	...	...	...
Thirsk . .	36	49	84	127	120	140	145	153	168	179	192	...	280
Durham . .	51	55	*118*	...	...	152	151	170	177	...	...	...	...
Burnopfield . .	51	97	97	128	...	149	152	...	176	194	...	...	...
Corbridge-on-Tyne	47	84	...	...	149	152	150	161	174	201	...	...	...
Blyth . . .	51	53	72	111	...	144	149	168	172	184	189	...	...
Galashiels . .	...	64	102	122	131	151	152	163	162	...	...	...	...
West Foulden .	46	...	102	...	135	144	148	158	178	198	199	...	...
J													
Forgandenny .	...	...	...	...	...	165	164	...	...	...	...	...	...
Kirriemuir . .	...	...	...	...	...	...	...	160	...	192	183	...	...
Durris. . .	...	...	96	128	...	151	154	160	165	187	181	202	287
Crathes . .	47	45	98	130	...	...	156	...	...	...	182	...	...
Aberdeen . .	...	97	*125*	...	...	157	153	...	...	...	187	...	...
K													
Invermoidart .	...	...	108	...	...	...	152	172	175	212	...	...	286
Beauly . .	...	46	123	137	139	153	160	172	173	191	187	...	306
Dingwall . .	40	68	99	123	...	144	162	162	166	...	197	...	...
Inverbroom. .	...	64	112	...	...	...	...	...	...	...	...	...	...
Watten . .	...	79	...	...	...	...	...	*207*	...	214	...	...	...

The dates in *italics* have not been taken into consideration when calculating the means given in Table IV.

nightingale made their appearance remarkably late. The only deficient farm crop was that of barley. The yield of wheat, oats, and beans was rather above the average, that of peas and hay very good, while the crops of turnips, mangolds, and potatoes taken together were the most abundant for many years. The yield of apples was under average, and that of pears and plums much under average. On the other hand, the crops of raspberries, currants, gooseberries, and strawberries were almost everywhere unusually good. As regards the farm crops, this was the third good year in succession, although compared with 1906 and 1907 the yields in 1908, except in the case of turnips, mangolds, and potatoes, were very inferior.

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TABLE IV.—Mean Dates (Day of Year) for the First Flowering of 13 Plants in 1908, and their Variations from the 18 Years' Average, 1891-1908.

Plants.	A England, S.W.			B Ireland, S.			C England, S.			D England, Mid.		
	1908.	Average for 18 Years.	Variation from Average.	1908.	Average for 18 Years.	Variation from Average.	1908.	Average for 18 Years.	Variation from Average.	1908.	Average for 18 Years.	Variation from Average.
Hazel	42	39	+3	29	31	−2	34	35	−1	47	42	+5
Coltsfoot	55	56	−1	66	56	+10	57	62	−5	65	65	0
Wood Anemone	90	85	+5	79	75	+4	87	83	+4	96	89	+7
Blackthorn	98	92	+6	97	81	+16	106	97	+9	113	100	+13
Garlic Hedge-Mustard	116	107	+9	119	111	+8	115	110	+5	121	114	+7
Horse-Chestnut	130	121	+9	141	121	+20	132	127	+5	138	131	+7
Hawthorn	137	131	+6	140	129	+11	140	132	+8	143	134	+9
White Ox-Eye	151	147	+4	151	143	+8	147	142	+5	150	149	+1
Dog Rose	161	156	+5	164	158	+6	159	158	+1	160	160	0
Black Knapweed	172	175	−3	186	182	+4	175	172	+3	173	178	−5
Harebell	200	195	+5	...	*186*	...	182	185	−3	180	190	−10
Greater Bindweed	191	186	+5	201	192	+9	190	189	+1	187	192	−5
Ivy	267	264	+3	265	256	+9	271	271	0	274	270	+4
Mean for the 13 Plants	139	135	+4	136*	128*	+8*	138	136	+2	142	140	+2

Plants.	E England, E.			F England, N.W.			G Ireland, N.			H Scotland, W.		
Hazel	41	36	+5	42	44	−2	36	50	−14	45	49	−4
Coltsfoot	68	63	+5	59	66	−7	73	70	+3	78	74	+4
Wood Anemone	95	88	+7	89	92	−3	91	87	+4	99	99	0
Blackthorn	115	98	+17	110	104	+6	111	101	+10	124	112	+12
Garlic Hedge-Mustard	121	111	+10	133	125	+8	105	*119*	−14	...	*122*	0
Horse-Chestnut	134	126	+8	141	132	+9	141	132	+9	149	142	+7
Hawthorn	140	131	+9	146	138	−8	147	140	+7	151	145	+6
White Ox-Eye	151	146	+5	158	153	+5	157	156	+1	164	160	+4
Dog Rose	160	158	+2	166	162	+4	171	166	+5	170	166	+4
Black Knapweed	177	179	−2	191	189	+2	195	200	−5	184	199	−15
Harebell	189	189	0	190	189	+1	202	*194*	+8	191	191	0
Greater Bindweed	194	193	+1	207	195	+12	220	204	+16	203	*198*	+5
Ivy	267	265	+2	288	282	+6	285	278	+7	284	*277*	+7
Mean for the 13 Plants	142	137	+5	148	144	+4	149	146	+3	153*	151*	+2*

Plants.	I England, N.E.			J Scotland, E.			K Scotland, N.			British Isles.		
Hazel	46	49	−3	47	*55*	−8	40	*53*	−13	41	44	−3
Coltsfoot	71	68	+3	71	*77*	−6	64	*75*	−11	66	67	−1
Wood Anemone	92	93	−1	97	*101*	−4	110	*99*	+11	93	90	+3
Blackthorn	122	109	+13	129	*112*	+17	130	*110*	+20	114	101	+13
Garlic Hedge-Mustard	133	121	+12	...	*127*	...	139	*125*	+14	122	116	+6
Horse-Chestnut	146	141	+5	158	*142*	+16	148	*140*	+8	142	132	+10
Hawthorn	149	142	+7	157	*146*	+11	158	*144*	+14	146	137	+9
White Ox-Eye	161	160	+1	160	*160*	0	169	*158*	+11	156	152	+4
Dog Rose	170	170	0	165	*172*	−7	171	*170*	+1	165	163	+2
Black Knapweed	191	196	−5	189	*189*	0	209	*187*	+22	186	186	0
Harebell	193	191	+2	183	*202*	−19	192	*200*	−8	190	193	−3
Greater Bindweed	...	198	...	202	*203*	−1	...	*201*	...	199	195	+4
Ivy	280	282	−2	287	*282*	+5	296	*280*	+16	279	273	+6
Mean for the 13 Plants	146*	143*	+3*	154*	*153**	+1*	152*	*145**	+7*	146	142	+4

* For 12 Plants.

\+ indicates the number of days later than the average date.
− ,, ,, ,, earlier ,, ,,
0 ,, average date (1891-1908).
The dates in *italics* are approximate averages.

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Observers' Notes.

December 1907.—*Altarnon* (A)—4th. A few raspberries, alpine strawberries, and blackberries to be found. *Whitney-on-Wye* (A)—20th. Roses still in flower. *Ovoca* (B)—The sweet-scented verbena on the house remained green and unharmed by frost until the 23rd. *Churt* (C)—25th. Roses, laurestinus, cowslips, violets, and other flowers still in bloom on Christmas Day. *Purley* (C)—In Christmas week counted 45 different wild flowers still out round Purley and on Walton Heath. *Hodsock* (D)—On Christmas Day gathered several "Gruss an Teplitz" roses. *Hatfield* (E)—"Dorothy Perkins" rose still in flower. *Clenchwarton* (E)—Sufficient roses gathered to decorate a dinner-table on Christmas Day. *Betley* (F)—Pansies, roses, and cowslips out on Christmas Day.

January 1908.—*Whitney-on-Wye* (A)—15th. Much damage done to broccoli and Brussels sprouts from recent frost. *Berkhamsted* (D)—5th. Last rose bloom of the season destroyed by frost, 23 days later than the average date of its destruction in the previous 22 years. 20th. Winter aconite in flower, its average date for the previous 21 years. *Tacolneston* (E)—Very few fieldfares this winter.

February.—*Ovoca* (B)—16th. Frog spawn first seen. *Bembridge* (C)—19th. Prunus pissardi in flower. *Churt* (C)—16th. Frog spawn first seen. *Llangollen* (F)—22nd. Trees broken and torn up by the roots by a brief but fierce storm of rain, hail, and wind.

March.—*Berkhamsted* (D)—24th. An early Rivers' peach on a south wall in blossom, 2 days later than its average date for the previous 22 years. *Beeston* (D)—11th. Water wagtails reappeared. *Bowdon* (F)—27th. Frog spawn first seen. *Milford* (G)—15th. Frog spawn first seen.

April.—*Marwnan* (A)—23rd-27th. Frequent hail and frost. Azaleas which had come into flower were cut to pieces. Potatoes mostly cut to the ground. *Brixham* (A)—15th. Wheatear first seen. *Whitney-on-Wye* (A)—24th. Asparagus cut down, and much pear and plum blossom damaged by frost and snow. *Tallow* (B)—24th. Potatoes, roses, etc., blackened by frost. *Bagenalstown* (B)—Many shrubs that had survived the winter were killed by the frosts of this month. *Ovoca* (B)—Frost and snow towards end of month, which did much damage to the fruit blossom, also buds of rhododendrons, laburnums, white lilac, etc. *Kilcullen* (B)—Pear and plum blossom injured by frost. *Bembridge* (C)—25th and 26th. Swallows picked up half dead with the cold following the heavy fall of snow. *Botley* (C)—25th. The branches of many trees broken by the snow; a large apple tree was uprooted; no wind, only the weight of snow. 26th. During the 3 days of snow the growth of grass and garden plants under the snow covering 11 inches deep was wonderful. *Churt* (C)—11th. Wryneck first heard. 22nd. Willow-wren first seen. *Purley* (C)—5th. Picked some white and blue sweet violets. *Harefield* (D)—18th. Wryneck first heard. *St. Albans* (*Glenferrie Road*) (D)—On going through the woods on the 26th many of the branches of the trees were found to be broken down by the weight of the snow. Many young birds perished through the nests becoming full of snow. *Farnborough* (D)—Gooseberries nearly all destroyed by the snowstorm and frosts of the 23rd and 24th. *Northampton* (D)—25th. Damage by snowstorm to trees and shrubs, evergreens especially, was very great. A plantation of Scotch firs some 15 feet high were about half of them torn up and broken down by the wind and snow. A birch 3 feet high was weighed down so as to be actually prostrate. *Stone* (D)—Martins made their appearance 11 days later and sand-martins 15 days later than their average dates in the previous 16 years. *Hodsock* (D)—24th.

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TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1908.

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey-Bee.	Wasp.	Small White Butterfly.	Orange-Tip Butterfly.	Meadow-Brown Butterfly.
A											
Mawnan	7	110	121	...	124	...	...	106	90	138	159
Altarnon	6	93	118	134	119	276	72	94	103	136	178
Brixham	27	108	107	...	...	...	...	...	99	...	...
Starcross	22	107	119	...	136	284	52	122	108	137	176
Clifton	...	119	111	...	...	...	...	...	122	...	...
Penarth	...	...	...	...	...	...	*101*	...	120	149	186
Bridgend	16	109	115	...	...	276	81	*148*	131	152	141
Little Mill	23	119	117	*144*	*152*	279	33	77	81	*100*	123
Aberystwyth	...	109	120	...	125	*254*	43	107	108	144	173
Whitney-on-Wye	27	119	119	...	...	278	83	123	119	152	181
B											
Tallow	...	119	114	...	...	...	35	...	124	124	147
Ferns	6	120	116	...	...	277	71	115	108	130	128
Bagenalstown	15	117	122	...	...	...	35	138	108	...	...
Ovoca	18	121	121	...	...	279	33	89	109	122	122
Kilcullen	...	99	120	...	123	...	63	122	106	123	140
Geashill	...	119	122	...	...	...	41	108	112	133	181
C											
Bembridge	22	88	117	121	...	...	...	...	100	148	171
Weymouth	...	121	119	...	142	...	88	*152*	100	149	177
Buckhorn Weston	16	119	118	...	135	265	...	...	122	132	166
Havant	18	103	110	113	137	316	73	...	98	144	172
Botley	2	91	106	122	124	281	39	60	100	138	175
Birdham	15	98	*86*	...	...	332	...	99	98	141	...
Hellingly	*93*	117	115	125	...	...	46	124	122	...	...
Muntham	...	119	104	120	148	285	45	101	122	123	...
Dover	...	122	...	...	...	274	...	...	...	...	...
Staplehurst	*52*	114	*75*	118	126	...	41	52	*62*	134	153
Maidstone	17	*131*	116	121	...	...	84	99	100	...	...
Chiddingfold	38	120	114	...	136	...	...	...	121	140	...
Cranleigh	22	104	104	106	...	...	83	98	130	137	178
Coneyhurst	...	124	113	119	124	*250*	77	122	94	...	...
Churt	28	117	114	120	146	286	41	87	99	139	179
Purley	26	...	120	120	149	286	84	...	122	...	...
Marlborough	*54*	117	118	126	123	...	...	...	100	140	172
D											
Oxford	...	120	120	120	...	...	...	...	121	...	...
Chadlington	...	...	...	...	...	...	...	*237*	...	...	...
Harefield	...	124	114	121	...	271	*108*	...	108	145	...
Chesham	28	110	108	...	...	275	55	138	99	138	...
Watford	...	110	117	123	...	265	50	119	107	...	...
St. Albans (New Green's Farm)	12	119	118	110	138	290	39	99	122	139	175
St. Albans (Glenferrie Road)	...	105	115	123	130	294	...	...	122	...	...
King's Langley	...	*126*	...	120	...	...	...	140	123	...	...
Berkhamsted	18	115	120	121	*109*	272	50	91	122	152	...
Harpenden	37	117	118	125	...	...	99	122	...	149	*108*
Ross	18	111	120	120	149	...	54	90	108	138	...
Dymock	27	105	112	...	139	277	69	108	103	...	...

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TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1908—*continued.*

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey-Bee.	Wasp.	Small White Butterfly.	Orange-Tip Butterfly.	Meadow-Brown Butterfly.
West Malvern	8	123	118	...	137	271	86	116	127	131	154
Farnborough	8	107	115	124	128	277	35	136	122	148	176
Stone	6	99	115	...	127	309	83	147	123	...	...
Ketton	28	119	119	124	138	...	37	...	119	144	174
Beeston	...	122	120	...	...	275	83	90	123	...	...
Hodsock	37	120	118	123	135	...	37	118	122	152	182
Macclesfield	37	128	130	...	...	277	101	83	*83*	...	...
Belton	17	118	116	119	135	...	37	118	126	143	...
Altofts	...	...	...	...	...	...	...	77	*148*	*173*	185
Ripley	29	118	120	...	...	265	34	122	137	156	...
E											
Hatfield	*48*	123	116	121	*150*	280	83	83	*148*	...	166
Sawbridgeworth	18	108	120	...	137	...	37	99	107	144	...
Hitchin	17	122	120	121	...	306	...	...	...	152	...
Odsey (Ashwell)	...	121	120	126	124	280	...	...	...	...	...
Shelford	...	120	117	118	130	...	37	106	106	140	175
Bocking	...	...	117	118	...	...	...	...	...	...	...
Lexden	26	121	120	120	130	299	41	...	99	133	...
Roxton	2	116	121	...	133	...	68	...	...	...	...
Carleton-Forehoe	27	*91*	120	130	134	284	37	119	122	136	...
Tacolneston	27	120	120	...	...	300	39	...	...	141	...
Eaton (Norwich)	...	...	124	...	...	...	...	...	...	...	...
Southacre	...	120	119	117	133	303	78	123	129	148	...
Brunstead	37	114	116	...	130	280	69	127	123	141	182
Hevingham	...	...	118	...	...	...	...	...	...	...	...
Clenchwarton	2	119	118	125	...	280	74	...	106	149	...
Peterborough	26	108	108	110	125	307	...	...	108	...	...
F											
Llangollen	18	102	118	...	132	271	98	123	123	149	...
Betley	39	108	120	...	145	292	87	...	128	148	189
Bowdon	...	120	120	...	131	279	66	86	131	...	...
Birkdale (Southport)	...	117	120	...	...	273	87	87	99	...	...
Preston	27	116	121	...	123	...	83	131	123	...	...
Ambleside	38	122	120	...	128	*269*	72	148	129	168	185
Cronkbourne	36	*131*	124	...	...	...	...	106	136	...	...
G											
Ardgillan	16	119	119	...	...	274	37	128	109	147	182
Edgeworthstown	26	121	121	...	*163*	277	...	...	122	...	...
Westport	14	120	122	...	...	273	...	...	...	...	...
Chanter Hill	33	109	119	...	...	284	76	128	128	134	150
Loughbrickland	33	119	120	...	...	278	...	...	111	121	...
Saintfield	25	121	121	...	143	269	99	143	130	147	...
Antrim	33	115	116	...	136	282	*128*	95	98	...	...
Altnafoyle	35	124	122	...	...	...	108	...	139	145	184
Milford	19	122	123	...	...	275	47	...	136	134	181
H											
Kirkmaiden	28	119	123	...	...	286	85	124	...	139	...

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TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1908—*continued.*

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey-Bee.	Wasp.	Small White Butterfly.	Orange-Tip Butterfly.	Meadow-Brown Butterfly.
New Galloway	38	121	121	...	...	262	37	144	...	...	...
Jardington	38	121	119	...	138	275	...	108	149	...	181
Moniaive	19	121	122	...	...	...	...	150	148	...	...
Port Ellen	23	123	121	...	...	...	108	135	133	*180*	174
Salen	...	*136*	125	...	*169*	...	...	...	130	...	...
I											
Lincoln	36	125	122	122	135	280	83	...	133	140	182
Thirsk	35	121	121	...	...	285	47	54	122	152	197
Durham	39	122	129	...	131	...	...	88	...	*177*	...
Burnopfield	*60*	124	125	...	...	...	*16*	125	...	...	...
Corbridge-on-Tyne	37	120	120	...	...	...	...	...	...	...	...
Blyth	41	120	122	...	...	290	...	...	...	...	...
Galashiels	18	121	122	...	...	271	70	130	131	...	...
West Foulden	37	120	123	...	142	...	71	136	152	...	182
J											
Forgandenny	*61*	129	128	...	131	...	...	...	...	...	...
Kirrienuir	...	127	122	...	...	...	...	149	...	...	...
Durris	...	122	121	...	143	269	...	...	137	152	172
Crathes	21	122	119	...	...	...	*16*	...	138	...	...
Aberdeen	18	122	126	...	...	252	105	...	...	...	...
K											
Invermoidart	40	...	127	...	...	...	...	111	123	...	...
Beauly	41	133	127	...	...	253	37	135	152	...	...
Dingwall	13	130	133	...	...	...	*12*	108	131	...	...
Inverbroom	...	...	126	...	...	...	...	...	...	...	...
Watten	...	...	162	...	...	...	71	...	148	...	204
Mean Dates for the British Isles in 1908	24 Jan. 24	116 Apl. 25	119 Apl. 28	121 Apl. 30	134 May 13	281 Oct. 7	63 Mar. 3	112 Apl. 21	118 Apl. 27	141 May 20	171 June 19
Mean Dates for 1891-1908	Jan. 23	Apl. 18	Apl. 23	Apl. 22	May 15	Oct. 12	Feb. 25	Apl. 13	Apl. 19	May 10	June 13

The dates in *italics* have not been taken into consideration when calculating the means for the British Isles.

Daffodils laid flat by the snow. *Altofts* (D)—24th. Snow and very cold winds. Potatoes killed and young shoots and shrubs. *Hertford* (E)—The heavy fall of snow towards the end of the month broke down the boughs of hawthorns, gorse, and other trees and shrubs. *Lexden* (E)—The snowstorm did much damage to the Cedars of Lebanon in the neighbourhood. *Brunstead* (E)—25th. Deep fall of snow. Many birds' nests forsaken. *Llangollen* (F)—24th Heavy

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TABLE VI.—Estimated Yield of Farm Crops in 1908.

Description of Crop.	England.						Scotland.			Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H W.	J E.	K N.	B and G S. and N.	
	%	%	%	%	%	%	%	%	%	%	%
Wheat	+ 1	+ 2	− 2	+ 1	o	+ 1	+ 5	+ 3	+18	+10	+ 2
Barley	− 4	− 3	− 1	− 6	− 5	+ 3	+ 1	− 1	+ 8	+10	o
Oats	− 3	− 3	− 1	− 2	o	+ 1	+ 3	+ 4	+12	+ 6	+ 2
Corn Harvest began, average Date, day of Year	224	220	226	222	235	235	...	...	...	...	227
Beans	+ 9	+ 4	− 1	+ 2	+ 8	+ 5	+ 8	− 1	+25	− 3	o
Peas	+ 8	+ 5	+ 5	+ 4	+ 5	+ 5	+ 1	+ 3	+25	− 6	+ 3
Potatoes	+12	+19	+17	+19	+13	+12	+10	+14	+13	+22	+19
Turnips	− 1	+10	+14	+ 7	+13	+17	+17	+16	+32	+18	+15
Mangolds	− 7	+10	+ 9	+12	+ 8	+ 7	+21	+13	+44	+20	+10
Hay (Permanent Pastures)	o	+ 9	+ 4	o	+ 6	+ 1	+ 5	− 2	+23	− 4	− 1
Hay (Clover, etc.)	+ 1	+16	+ 7	+ 9	+ 1	+ 2	− 1	− 3	+16	−14	+ 1

Symbols:—+ = Over. − = Under. o = Average.

The variations from the average in the above-mentioned crops have been obtained from the *Agricultural Returns*, 1908 (*Produce of Crops*), issued by the Board of Agriculture, while the average dates of the Harvest have been derived from returns which appeared in the *Agricultural Gazette*, July 27 to August 24.

TABLE VII.—Estimated Yield of Fruit Crops in 1908.

Description of Crop.	England.						Scotland.	Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H, J, and K W. E. and N.	B and G S. and N.	
Apples	o	+	−	−	o	+	−	o	−
Pears	−	−	−	−	−	−	−	−	−
Plums	−	−	−	−	−	o	−	−	−
Raspberries	+	+	+	o	+	+	o	+	+
Currants	+	+	o	o	+	+	o	+	+
Gooseberries	+	+	o	o	+	+	o	o	+
Strawberries	+	+	+	+	+	+	+	+	+

Symbols:—+ = Over. − = Under. o = Average. This Table has been compiled from returns which appeared in the *Gardeners' Chronicle*, August 1, 1908.

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TABLE VIII.—VARIATIONS FROM THE AVERAGE IN TEMPERATURE, RAINFALL, AND SUNSHINE, 1907-8.

WINTER 1907-8.

Temperature.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
December .	+1·5	+0·7	+3·3	+2·6	+3·4	+1·4	+1·2	+0·8	+1·7	+0·8	+1·1
January . .	−3·0	−1·5	−2·7	−2·6	−2·0	−2·3	−0·2	−1·1	−1·9	−1·1	+1·7
February . .	+2·0	+3·0	+1·8	+2·8	+2·6	+2·4	+3·0	+3·2	+2·4	+3·1	+2·5
Winter . .	+0·2	+0·7	+0·8	+0·9	+1·3	+0·5	+1·3	+1·0	+0·7	+0·9	+1·8

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
December .	+1·6	+1·3	+1·1	+1·0	+0·7	+1·1	+0·6	+0·8	+0·5	+1·1	−0·1
January . .	−2·0	−1·4	−1·0	−1·2	−0·8	−0·1	+0·1	−0·2	−0·7	−0·3	−0·5
February . .	−0·5	−0·9	−0·7	−0·4	+0·1	+0·6	+0·5	+0·3	0·0	0·0	+1·6
Winter . .	−0·9	−1·0	−0·6	−0·6	0·0	+1·6	+1·2	+0·9	−0·2	+0·8	+1·0

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December .	−16	−15	+20	−7	+9	+4	−7	−22	−6	+1	+5
January . .	+22	+3	+36	+9	+14	+50	+25	−14	+18	+14	+9
February . .	−32	−26	−2	−6	−23	−19	−26	+7	+10	+21	−24
Winter . .	−26	−38	+54	−4	00	+35	−8	−29	+22	+36	−10

SPRING 1908.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
March . .	−2·5	−2·0	−2·6	−2·6	−2·3	−2·4	−1·2	−1·9	−2·2	−2·7	−1·1
April . .	−2·4	−2·1	−2·6	−2·5	−2·4	−2·5	−2·2	−2·3	−1·9	−3·0	−2·6
May . .	+0·2	+1·0	+0·7	+1·7	+2·3	+1·0	+0·4	+0·9	+2·6	+0·7	−0·1
Spring . .	−1·6	−1·0	−1·5	−1·1	−0·8	−1·3	−1·0	−1·1	−0·5	−1·7	−1·3

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
March . .	+0·9	+0·8	+0·8	+1·0	+0·6	+0·7	+1·3	+1·2	+0·8	+1·5	−0·3
April . .	+0·6	+0·1	+1·0	+1·4	+1·0	+1·4	+0·7	−0·1	+0·7	+0·1	+0·4
May . .	0·0	+0·1	−0·2	−0·3	−0·4	+0·1	0·0	+0·1	+0·1	0·0	+0·5
Spring . .	+1·5	+1·0	+1·6	+2·1	+1·2	+2·2	+2·0	+1·2	+1·6	+1·6	+0·6

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March . .	+7	−10	−17	−28	−25	−11	+7	−32	−20	−23	+8
April . .	−10	−5	+4	−25	−11	+5	+17	00	−37	−33	−10
May . .	−35	−32	−19	−12	−9	−10	−19	−12	−3	+8	−3
Spring . .	−38	−47	−32	−65	−45	−16	+5	−44	−60	−48	−5

\+ indicates above the average, − below it.

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TABLE VIII.—VARIATIONS FROM THE AVERAGE—*continued.*

SUMMER 1908.

Temperature.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
June . .	−0·6	−1·5	0·0	−0·6	−0·4	−1·2	−2·0	−0·9	−0·2	−0·4	−1·2
July . .	+0·5	+0·9	+0·3	+0·4	−0·3	+0·1	+0·4	+0·9	+0·1	−0·4	−0·4
August . .	+0·1	+0·7	−0·9	−0·4	−0·5	−0·6	−0·2	−0·2	−0·5	−0·9	−0·9
Summer . .	0·0	0·0	−0·2	−0·2	−0·4	−0·6	−0·6	−0·1	−0·2	−0·6	−0·8
					Rain.						
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
June . .	−1·3	−0·8	−0·4	−0·2	−0·6	+0·7	+0·5	+0·5	−0·9	−0·6	+1·1
July . .	−0·4	−0·5	+0·1	−0·3	+0·4	+0·3	−0·6	−0·3	−0·4	−0·8	−2·0
August . .	+0·2	−0·7	+0·5	−0·1	−0·1	0·0	−0·7	−0·5	−1·0	−1·2	−0·3
Summer . .	−1·5	−2·0	+0·2	−0·6	−0·3	+1·0	−0·8	−0·3	−2·3	−2·6	−1·2
					Sunshine.						
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June . .	+28	−13	+36	+20	+20	+3	−18	+6	+3	+11	−9
July . .	+18	+39	+19	+12	+2	+26	+25	−6	−9	−14	−7
August . .	+25	+9	+25	+14	+5	+27	+15	+32	+10	+14	+14
Summer . .	+71	+35	+80	+46	+27	+56	+22	+32	+4	+11	−2

AUTUMN 1908.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
September .	+0·6	+1·0	+0·2	+1·2	+1·2	+1·4	+1·0	+1·8	+2·2	+1·5	+1·7
October . .	+4·4	+5·6	+4·3	+4·7	+4·9	+5·0	+6·0	+5·9	+5·1	+5·8	+6·4
November .	+2·5	+3·7	+1·9	+2·8	+2·6	+2·2	+4·0	+2·5	+2·2	+2·1	+2·2
Autumn . .	+2·5	+3·4	+2·1	+2·9	+2·9	+2·9	+3·7	+3·4	+3·2	+3·1	+3·4
					Rain.						
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
September .	+0·1	+2·8	−0·5	+0·3	−0·4	+0·6	+2·6	+1·4	+0·1	+1·7	+1·1
October . .	−1·5	−1·2	−1·3	−1·1	−1·0	−1·7	−2·0	−2·6	−1·6	−0·9	−3·2
November .	−2·1	−1·4	−1·5	−0·9	−0·9	−0·1	−0·8	−1·0	−0·8	−0·6	+0·2
Autumn . .	−3·5	+0·2	−3·3	−1·7	−2·3	−1·2	−0·2	−2·2	−2·3	+0·2	−1·9
					Sunshine.						
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September .	−2	−29	+32	−5	+29	−1	−33	−35	+11	−40	−27
October . .	+10	−12	+23	−4	+13	+30	−1	−34	−3	−1	+8
November .	+34	−15	+51	+11	+21	+28	+4	−1	+3	+13	+10
Autumn . .	+42	−56	+106	+2	+63	+57	−30	−70	+11	−28	−9

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

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TABLE IX.—Supplementary Observations in 1908.

BIRDS.

Chiff-Chaff (first heard).

Station.	District.	Date.
Ovoca	B	April 8.
Oxford	D	,, 20.
Ross	D	,, 1.
Stone	D	,, 17.
Saintfield	G	,, 16.

Swift (first seen).

Brixham	A	May 9.
Bridgend	A	,, 5.
Ovoca	B	,, 8.
Cranleigh	C	,, 18.
Coneyhurst	C	,, 6.
Churt	C	,, 3.
Oxford	D	,, 1.
Harefield	D	,, 14.
St. Albans (Glenferrie Road)	D	,, 2.
Ross	D	April 29.
Stone	D	May 1.
Odsey (Ashwell)	E	,, 4.
Altnafoyle	G	,, 15.
New Galloway	H	,, 9.
Corbridge-on-Tyne	I	,, 25.

Corncrake (first heard).

Station.	District.	Date.
Bridgend	A	May 4.
Stone	D	April 23.
Preston	F	May 3.
Cronkbourne	F	,, 3.
Chanter Hill	G	April 15.
Altnafoyle	G	May 3.
Moniaive	H	,, 4.
Corbridge-on-Tyne	I	,, 2.
Durris	J	,, 16.

PLANTS.

Winter Aconite.

Whitney-on-Wye	A	Feb. 6.
Bembridge	C	Jan. 19.
Churt	C	,, 17.
Watford	D	,, 1.
Berkhamsted	D	,, 20.
Clenchwarton	E	,, 4.
Cronkbourne	F	,, 20.
Edgeworthstown	G	,, 26.
New Galloway	H	Feb. 6.

fall of snow, but little damage done, as frost was not severe. *Birkdale* (*Southport*) (F)—The heavy snow and cold winds towards end of month spoilt the setting of the pear blossom. *Ardgillan* (G)—24th and 25th. Horse-chestnut bloom buds destroyed by frost. *Edgeworthstown* (G)—25th. Severe frost and deep fall of snow. *Antrim* (G)—24th. Snow and severe frost, which did much injury to aucubas, weigelias, syringas, etc. Much of the bush fruits was destroyed. *Jardington* (H)—30th. Sand-martin first seen. *Thirsk* (I)—24th. Severe frost, which damaged the early plum blossom. Ice on the small ponds strong enough to bear. *Galashiels* (I)—During the week ending the 25th severe frosts and snow. *Durris* (J)—For a week after the 19th, ice and snow almost every morning. *Beauly* (K)—Severe frosts on the 23rd, 24th, and 25th, which blackened the shrubs and made rhubarb quite soft.

May.—*Whitney-on-Wye* (A)—26th. Owing to attacks of wireworm some fields have become nearly bare. *Ovoca* (B)—Masses of blossom on the hawthorn. *Botley* (C)—1st. Willow warbler first seen. 23rd. Cuckoo sang 103 times without stopping at 5.30 a.m. *Muntham* (C)—A very large number of queen wasps observed. *Coneyhurst* (C)—4th. Sand-martin first seen. *Churt* (C)—The snowstorms of the 24th and 25th April and the following frosts have damaged the promising young shoots of the tea roses. 5th. Nightjar first heard. 30th. First May-fly seen. *Purley* (C)—1st and 2nd. The effect of the heat on these two days was very striking, pears, plums, etc., bursting all at once into full bloom. *Oxford* (D)—19th. Elms and limes in full leaf. 23rd. Hawthorns, chestnuts, and lilac flowering sparsely.

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Harefield (D)—1st. House-martin first seen. Vegetation generally seemed to burst into life. *St. Albans* (*Glenferrie Road*) (D)—9th. Nightjar first heard. *Berkhamsted* (D)—1st. Wild cherry in my garden in flower, 14 days later than its average date for the previous 22 years. 15th.—Blenheim orange-apple in blossom 10 days later than its average date in the previous 22 years. Comparatively few flowers on lilac and laburnum. *Stone* (D)—17th. Nightjar first heard. *Beeston* (D)—1st. Vegetation making rapid advance owing to change to warmer weather. *Southacre* (E)—31st. A sand-pit unoccupied by sand-martins where last year there were 50 or 60 old birds. Hawthorn bloom scanty. *Llangollen* (F)—Slugs very destructive in the garden. *Corbridge-on-Tyne* (I)—1st. House-martin first seen. *Durris* (J)—Such full and fresh leaf on young trees as is seldom seen. 3rd. Sand-martin first seen. 4th. House-martin first seen.

JUNE.—*Bridgend* (A)—18th. Hay first cut. *Whitney-on-Wye* (A)—15th. Haymaking began. *Geashill* (B)—Remarkable number of white butterflies this summer. *Weymouth* (C)—Orange-tip butterflies are unusually abundant this year. *Buckhorn Weston* (C)—Droughts, lasting from June 18 to July 3, and from July 18 to August 18. Strawberries suffered the most from lack of rain. *Coneyhurst* (C)—The common large white butterfly very plentiful. *Churt* (C)—4th. First swarm of bees—the latest date since 1879. 7th. Potatoes and young bracken killed by frost in lower part of parish. *Harefield* (D)—15th. Haymaking began. *St. Albans* (*Glenferrie Road*) (D)—13th. Haymaking began. *Harpenden* (D)—15th. First wheat ear out of sheath, or 2 days later than the average date for the previous 16 years. *Farnborough* (D)—No lady-birds, and but few butterflies. *Cronkbourne* (F)—18th. Hay harvest began. *Antrim* (G)—Butterflies less numerous than usual this year. *Moniaive* (H)—27th. Hay first cut. *Thirsk* (I)—15th. First hay cut.

JULY.—*Whitney-on-Wye* (A)—25th. Haymaking finished. *Churt* (C)—2nd. Lawns quite brown, a few patches still brown on the 26th. *Ketton* (D)—1st. Remarkably light night. Insects remained on the wing for an hour beyond their usual time. *Beeston* (D)—5th. Vegetation refreshed by rain—the first downfall since June 17. *Odsey* (E)—23rd. Began cutting winter oats. *Clenchwarton* (E)—White butterflies numerous. *Botley* (F)—22nd. Hay harvest ended. *New Galloway* (H)—21st. Swift last seen. *Jardington* (H)—1st. So bright late in the evening that the smallest print could be read. A friend told me he was weeding in his garden between 11 p.m. and midnight. *Thirsk* (I)—1st. Hardly a blade of grass to be seen on the lawn. *Durris* (J)—8th. Cuckoo last heard.

AUGUST.—*Whitney-on-Wye* (A)—1st. Harvest began. *Ovoca* (B)—Garden, shrubs, etc., suffering from drought. Scarcely any wasps till the middle of the month, after which they were very numerous. *Geashill* (B)—Wasps numerous. *Botley* (C)—White cabbage butterflies very numerous in the first week. 10th. Country dried up. 16th. Rain at last. *Chadlington* (D)—26th. The grass much revived after a few rainy days following 4 dry weeks. *Harefield* (D)—3rd. Oats first cut. 8th. Wheat first cut. 14th. Barley first cut. *Kings Langley* (D)—5th. First wheat cut. *Beeston* (D)—But few wasps or butterflies. 27th. Many apples blown down by strong winds. *Hodsock* (D)—11th. First day of harvest. No apricots or peaches this year. *Odsey* (E)—3rd. First wheat cut. *Bocking* (E)—Very few wasps. 10th. Harvest began. *Brunstead* (E)—Scarcity of wasps, numerous daddy-longlegs. *Clenchwarton* (E)—6th. Harvest began. *Cronkbourne* (F)—12th. Corn harvest began. *Jardington* (H)—26th. Corn harvest began. *Moniaive* (H)—25th. Corn harvest began. *Port Ellen* (H)—24th. Corn harvest began.

SEPTEMBER.—*Whitney-on-Wye* (A)—24th. Harvest finished. 28th. More wasps now than all the summer. Very few mushrooms. *Botley* (C)—At the

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end of the month grass was very thick and growing as in spring. *Churt* (C)—3rd. Very few wasps. *Purley* (C)—A splendid crop of blackberries. *St. Albans* (*New Green's Farm*) (D)—Very few wasps this autumn. *Hodsock* (D)—12th. Harvest finished. *Bocking* (E)—23rd. Harvest finished. *Brunstead* (E)—Harvest not finished till the 24th. *Clenchwarton* (E)—Holly berries abundant. 16th. Harvest ended. *Llangollen* (F)—Corn standing cut in the fields for 5 weeks until discoloured and spoilt. *Altnafoyle* (G)—Very few wasps this year. *Jardington* (H)—Wasps less numerous than usual. *Corbridge-on-Tyne* (I)—Very few wasps. *Durris* (J)—24th. Last martin seen.

OCTOBER.—*Whitney-on-Wye* (A)—Blackberries not plentiful. *Weymouth* (C)—Three pear trees in my gardens were covered with flowers during part of October and November. *Botley* (C)—16th. Large white butterfly seen. 18th. Small white butterfly seen. *Churt* (C)—22nd. Dahlias killed by frost. *Harefield* (D)—4th. Martins last seen. *Dymock* (D)—25th. Begonias and nasturtiums blackened by frost. *Berkhamsted* (D)—24th. Dahlias killed by frost, 11 days earlier than the average date of their destruction in the previous 23 years. *Betley* (F)—23rd. Dahlias killed by frost. *Birkdale* (*Southport*) (F)—Apples and pears ripened too quickly and are not keeping well. *Cronkbourne* (F)—25th. Dahlias killed by frost. *Milford* (G)—Wild roses, raspberries, and strawberries in flower, also a pear. *Durris* (J)—Blackberries very plentiful. 7th. Harvest completed. 14th. Many wild geese passing south.

NOVEMBER.—*Tiverton* (A)—Autumn tints very brilliant, and lasted much longer than usual. 9th. Raspberries were gathered here in 3 different gardens. 25th. Roses still in flower. 30th. Hawthorns are in flower in 2 gardens, one of them covered with blossom. *Whitney-on-Wye* (A)—Wasps numerous. *Ovoca* (B)—Autumn tints very late. *Geashill* (B)—Autumn tints very fine. Trees held their leaves well till middle of month. *Botley* (C)—19th. Elm trees in full leaf—all golden yellow. *Maidstone* (C)—Roses still blooming in the gardens, cowslips also in flower. *Chiddingfold* (C)—Spring weather up to Christmas. *Coneyhurst* (C)—Roses in good bloom at end of month. *Churt* (C)—16th. The fall of the leaves, though late, was very rapid when it began. *Purley* (C)—The elms held their leaves until about the 24th. Roses still in flower at the end of month. *St. Albans* (*New Green's Farm*) (D)—Grass has made remarkable growth. *Ross* (D)—16th. Dahlias killed. *Stone* (D)—2nd. Redwing and fieldfare first seen. *Hodsock* (D)—7th. Dahlias killed by frost. No roses after the 9th. *Odsey* (E)—6th. Trees generally have now their full autumn tints. 30th. Trees now bare of leaves, except a few beech and a slight sprinkling still on some common elms. *Lexden* (E)—2nd. Trees holding their leaves longer than usual. *Tacolneston* (E)—10th. Dahlias killed by frost. 26th. Autumn tints have been very beautiful. *Clenchwarton* (E)—30th. Roses still in bloom. *Llangollen* (F)—10th. Dahlias killed by frost. *Betley* (F)—Plenty of berries on the holly. Many fruit trees covered with flower buds. *Birkdale* (*Southport*) (F)—Splendid autumn for late flowering plants. *Salen* (H)—An apple tree again in blossom. 22nd. Two full-blown roses gathered from a "Frau Karl Druschki" growing up the side of the house. *Thirsk* (I)—18th. Cattle still grazing in the open fields. Many wild plants flowering from new shoots. *Durris* (J)—9th. Fieldfares first seen. *Beauly* (J)—30th. Sweet peas, chrysanthemums, and auriculas still in flower, and the grass fields as green as in spring.

LIST OF LANTERN SLIDES SHOWN TO ILLUSTRATE THE PHENOLOGICAL REPORT.

1. A late year, but not quite so late as 1907. Eight forward and ten backward seasons.

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2. Hazel—February.—Red line represents average. E. district ought to come before midlands, and so curve would be smoother. In most districts came into flower early.
   Blackthorn—April.—In all districts late.
3. Hawthorn—May.—In all districts late.
   Dog-Rose—June.—Owing to warmer weather in May and early June, Dog-Rose a little nearer average than earlier flowers.
4. Ivy—October.—Late in most districts.
5. Swallow—April.—The latest date of which we have any record, and yet only nine days behind the average. Cold winds during most of April.
   Cuckoo—April.—Also the latest date, and yet only six days behind average.
6. Nightingale—April.—Latest on record.
   Swallow last seen—October.—Earliest with exception of 1904, when the same date.
7. Small white Butterfly—April.—Latest but one, one day earlier than in 1903.
8. View looking towards Crystal Palace on a clear day from Mr. Clark's residence at Purley.
9. October 1.—View looking north over Croydon from Purley on a foggy morning.
10. April 26.—View across Purley Downs from Riddlesdown Road, Purley.
11. April 25.—Effect of snowstorm in Stoke Bruerne Park, Northants.
12. April 26.—Taken at Newbury Park, Berks. Snow-man. Snow exactly eighteen inches deep, without drift.
13. Two figures walking down High Street, Berkhamsted on Easter Monday. The local photographer's two sons.
14. Nest of young rabbits.
15. A good crop of apples, Berkhamsted.
16. Holy thorn or Glastonbury thorn in leaf and blossom. Taken about December 7 at Greenbank Street, Somerset, about one mile distant from the parent tree on Wearyate Hill, Glastonbury.
17. A spray of Glastonbury thorn in flower from the same tree, December 1908, in a vase.
18-43. Photographs taken by Mr. F. A. Bellamy, 4 St. John's Road, Oxford, after the snow-storms of April 23-25.

DISCUSSION.

Mr. J. E. CLARK said that the photograph of the Glastonbury thorn shown by Mr. Mawley, was that of a tree planted by his brother, William Clark, about 1865; it was a fairly fast grower. According to legend the original tree was planted by Joseph of Arimathea in the first century; it was destroyed by the farmer of the land at the beginning of the eighteenth century, owing to the nuisance caused by the number of visitors that made the tree an object of pilgrimage. Numbers of cuttings were taken, however, and the present thorn is descended from the old original tree. It does not differ in appearance from the ordinary thorn, but flowers in an unusual way both about Christmas as well as in the spring. Holly was unusually scarce, it flowered freely, but the berries were few. In reference to apples, Mr. J. Cheal of Crawley had told him that the early ripening were of poor quality and had kept badly, while those that ripened later were far superior. The past autumn had been most favourable for sowing, and farmers were in excellent spirits in anticipation of a good crop this year. It remained to be seen if such favourable conditions were so good an omen as Dr. Shaw's investigations led one to expect. Mr. Clark

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then gave some comparative figures concerning plants, remarking that at Christmas 1907 he observed 50 garden and 45 wild plants in flower, and at Christmas 1908 he found exactly the same number. Many of the flowers were good specimens notwithstanding the fact that his garden was high up and in an exposed position.

Mr. T. L. K. Edge said that perhaps they would like to have a few remarks from a farmer of the Midlands. Owing to much rain they were unable to sow the wheat before the last day of January 1908, the latest date he could recollect, and consequently expected to get a poor crop, but owing to the splendid summer weather he thought the crop was the best he had ever had, although he could not say what the yield per acre would be, as he had not yet thrashed it. As to the good potato crop he thought that it was heavy at the time of lifting, but probably if it had been weighed two or three months after raising it would be found that nearly half would have to be thrown away owing to amount of disease.

Mr. R. Inwards referred to the Weather Prognostic of a favourable year following a late spring, and quoted the jingle—

Late Spring,
Great Blessing.

Such was the case in this instance.

Mr. F. J. Brodie said that the lateness of the season was a great blessing, otherwise the severe frosts at the end of April would have done a considerable amount of damage; as it was, they did comparatively none. It was a striking year for temperatures, as there were severe frosts at the beginning and end of the year, remarkable cold in April, and summer heat in October. It was a fine summer with much sunshine and little real warmth, owing to the fact that during the spells of fine weather the wind was chiefly from the West or North-west, which usually brought cool conditions in the summer months.

Mr. F. C. Bayard said that he had not seen any wasps this year, and Mr. Mawley had not mentioned them; he thought it was due to the wet weather in March which had destroyed the nests. Bees also were scarce as well as butterflies until the warm weather at the end of September, when many specimens were observed that had not been seen earlier in the year.

Mr. E. Mawley in reply said that he had listened to the remarks of Mr. Edge with much interest, as coming from a practical agriculturist who knew from experience how greatly farmers were dependent on the weather in the cultivation of their land. His explanation as to the potato crop was no doubt the true one, and that the tubers when lifted were in many cases not as sound as in the first instance they appeared to be. The reason he had not mentioned wasps in the report, was because the returns received from different parts of the country varied so greatly as to make it evident that very much depended on the amount of perseverance displayed in destroying wasps' nests. Taking the summer as a whole the only butterflies that were unusually numerous were the large and small garden white species.

The President (Mr. H. Mellish) said he wished to convey the thanks of the Society to Mr. Mawley for his excellent Reports, which became more valuable year by year. He thought the present one was as interesting as any.

Mr. L. C. W. Bonacina, in a note to the Secretary after the Discussion, wrote: The most noteworthy facts observed by me at Northwood, Middlesex, 16 miles north-west of London, during the year were (1) the rapid and luxuriant growth of grass when the weather turned hot immediately after the heavy snows during the last week in April, which has been noted as a general occurrence by Mr. Mawley throughout the country; and (2) the almost entire

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absence of beech-nuts. I noticed this failure of beech-nuts on the beech-wooded Chiltern hills in south Buckinghamshire as well as in Middlesex; in South Bucks the soil is chalky, but in Middlesex argillaceous mainly.

I understand that Mr. Mawley's Instructions to Phenological Observers are essentially these: to confine one's attention only to the same individuals of a plant-species year by year; and to record the date of *first* flowering of plants, song of birds, etc. No doubt Mr. Mawley has found this method to be the most practicable, and as it is time-honoured it deserves respect. I would like, however, to refer to a method which, if only it could be found practicable and capable of being carried out properly by the large body of phenological observers, would afford wider and more comprehensive results than Mr. Mawley's restricted method. I have outlined this method in *Symons's Meteorological Magazine* for October 1908, p. 175, and November 1908, p. 189, and indicated how it is theoretically at least superior to Mr. Mawley's. In making phenological observations our main object is, I think, twofold. First to ascertain approximately, if it is not possible to do so exactly, for a particular locality the date on or around which it may be said that a particular species of herb or tree, for instance, commences to leaf, flower, etc. This involves making a generalisation—based upon the observed condition of *all* the individuals of a particular species in a given locality, or at all events of a very considerable and representative number. Thus suppose that on May 7 within a defined walking beat or round in one of the southern shires, out of 100 hawthorn trees or bushes 5 have already commenced to flower, or are just upon the verge of doing so, as defined in the conventional way by the first appearance of stamens. Then suppose that by May 12 the number is 25 (including, of course, the previous 5) and that by May 20 it has risen to 50. Upon May 20, therefore, one-half of the total number of hawthorns are either past flowering, or are in the first stage of flowering; the other half remain with closed flower-buds, and some 5 will not open them till the first week of June, *i.e.* a month after the 5 very early individuals. Making a generalisation, therefore, it is fair to name May 20 as about the date on or around which *the* hawthorn and not *a* hawthorn is bursting into flower in the given locality.

The hawthorn happens to be down on Mr. Mawley's well-selected list of plants, but similar reasoning might be applied to other species of plants and animals. The method here briefly touched upon, without being thoroughly outlined, requires quick judgment, as well as acute powers of observation. Secondly, our object in making phenological observations is to compare the relative forwardness of wild life in the different parts of the British Isles. To this object I think Mr. Mawley's method is better adapted, and gives fairly reliable results on an average. An element of uncertainty, however, may be introduced from this circumstance, that an individual *usually* earlier than two or three neighbouring ones of the same species is liable to be occasionally, though perhaps very seldom, later. I should imagine that only comparatively few of a large body of observers would be able to carry out the proposed method satisfactorily; and if this is the case Mr. Mawley's method must continue to hold the field.

The Greenland Sea.

Mr. R. C. Mossman in 1906, and also in 1907, accompanied the steam whaler *Scotia* during her voyages to the Greenland Sea whale fishery, his object being to obtain an insight into the meteorological processes at work in that region. He has given the results of his observations in a paper on "The Greenland Sea: its Summer Climate and Ice Distribution," published in the *Scottish Geographical Magazine* for June. This is a welcome paper, as there is an absence of any general memoir dealing with the meteorology of the Greenland

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Sea. The specific area discussed is the ocean region north of 70°, between Spitzbergen and Greenland, and embracing the longitudes from 20° E. to 20° W., but information for coastal stations in west and east Greenland, Iceland, and Spitzbergen has also been made use of. The author states that the discussion of the temperature observations had not proceeded far, when it became evident that very great assistance in the drawing of the isothermal charts would be rendered by an accurate knowledge of the ice distribution. At the outside edge of this ice there is formed a fog zone which nullifies the solar effect and depresses the air temperature, so that it cannot rise much above the melting point of ice. Even in the height of summer, and with a sun that never sets, the direct solar influence is very feeble over the Greenland ice-fields; fine days are rare, and the relatively clear weather and strong solar radiation observed at land stations on the Greenland and Spitzbergen coasts are wholly absent. It is not surprising that the portion of the Greenland Sea west of the meridian of Greenwich has, for its latitude, the lowest mean summer temperature of the ocean area of the whole northern hemisphere, being but little above that experienced in sub-Antarctic zones, where the same conditions prevail, but in a more intense form.

The great influence of the fog and ice in lowering the summer temperature of the Greenland Sea has apparently hitherto not been fully recognised, as even the most recent isothermal charts show a temperature far too high, with the isotherms running approximately along parallels of latitude, whereas the dominating factor is the longitude at which the ice and sea meet.

Having spent six months, extending over two summers, in this region, Mr. Mossman could not help being impressed with the overwhelming influence of the persistent fog, and that in a manner which could hardly appeal to a meteorologist discussing the same data in a central bureau. When one has witnessed, however, the harassment in which the fog involves the whole industry of whale-fishing, leading frequently to the loss of valuable quarry, and has seen the extreme difficulties attending navigation, then the influence of the dominating climatic factor becomes impressed with redoubled force in a way that only personal experience could fully appreciate.

For the reason given, the position of the ice was obtained by direct measurement from the annual charts issued by the Meteorological Institute of Denmark. In drawing the isotherms, the mean monthly temperatures, based on observations extending over considerable periods for various places in Greenland, Iceland, and Spitzbergen, were entered on the maps. Then all the sea observations, based on 1400 days' observations, were arranged in groups embracing two and a half degrees of latitude and five degrees of longitude, and the means entered in their respective positions, special weight being attached to those obtained from a large number of observations. In order to fully utilise the data, mean temperatures were computed for other areas, in which the same conditions might be expected to prevail, and the resulting values put on the maps at the exact position shown from the average of the daily latitude and longitude of the observed positions.

To further aid in the accurate delineation of the isotherms, especially during June and July, "fog frequency" was calculated from the daily observations for specific areas, and the mean summer temperature and fog frequency obtained for various places. Normal climatological data for the period April to July were then prepared for each month, based on all the observations, and means showing the average temperature, variability of temperature, wind direction, and phenomena computed.

Mr. Mossman gives the mean temperature of each day from May 1 to July 15, along with some periods of exceptional cold and warmth; and also a complete discussion of the observations taken in 1906 and 1907.

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PERCOLATION, EVAPORATION, AND CONDENSATION.

By BALDWIN LATHAM, Mem. Inst. C.E., Mem. Inst. M.E., F.G.S., F.S.S., F.R.Met.Soc.

[Read April 21, 1909.]

PERCOLATION.

IN the course of carrying on an extensive series of investigations as to the probable volume of underground water furnished by the chalk formation around Croydon, the author considered it desirable at the same time to carry on some experiments on percolation and evaporation, and with this object he constructed two percolating gauges, in order to ascertain what was the actual quantity of rain which percolated into the ground within the chalk area in which he had made the investigation.

Each of these gauges was exactly one superficial yard in area, and contained one cubic yard of material, the edge of each of the gauges standing about an inch and a half above both the surface of the soil inside and outside the gauge. The edge of each gauge is sharp inside sloping outwards.

One of these gauges was filled with material taken from a chalk down in the neighbourhood of Croydon (Riddlesdown), and consisted exactly of the material which formed the first yard in depth of this down, including the natural growth of grass upon it. This is called the "chalk gauge," as it practically consists of chalk with a small amount of chalky soil on the surface.

The other gauge contains a section cut out of the valley in the Old Town of Croydon, with its natural soil and vegetation, consisting principally of gravel. This is called the "gravel gauge."

These gauges were started to work in the year 1878, and have been daily observed up to the present time, but they have been moved on three occasions since they were originally started. They were originally set up in 1878 at Nantwich House, Croydon, at a level of 259 ft. above Ordnance datum. In 1889 they were removed to Havelock Road, Croydon, and fixed at a level of 205 ft. above Ordnance datum. In 1893 they were again moved to the Old Town of Croydon, and fixed at a level of 158 ft. above Ordnance datum; and since the end of 1906 they have been located at Park Hill House, at a level of 265 ft. above Ordnance datum.

Two or more rain-gauges have always been at work alongside these percolators, so that the quantity of rain falling, and the quantity of water percolating, have been ascertained for every day of the year for thirty years past.

Table I. gives the monthly rainfalls taken with an 8-in. rain-gauge, fixed at a level of 1 ft. above the ground surface.

Since the year 1883 the quantity of grass which has been grown on each of these percolating gauges has been weighed, and a record kept of its weight. The amount of grass, however, does not appear to have had very material influence on the amount of rain percolating. Although a very much larger proportion of grass has been grown upon the gravel

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TABLE I.—Rainfall at Croydon. 8-inch Gauge 1 Foot above Surface of Ground.

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	2·600	·405	1·130	1·235	2·065	2·560	2·035	3·300	1·720	·860	1·135	2·590	2·100	·560	1·795
February	3·445	2·750	3·050	1·750	4·415	1·765	2·770	·455	·475	1·085	2·255	·945	·055	1·660	3·330
March	·532	·640	1·550	·875	1·005	1·695	1·690	1·305	1·855	3·045	2·135	2·435	2·245	1·565	·520
April	2·600	1·885	·495	2·970	1·545	1·285	2·010	1·470	1·735	1·905	2·250	2·075	·665	1·375	·085
May	3·695	·370	·920	·895	1·955	·635	3·140	4·350	1·505	·880	3·010	1·650	2·930	1·350	·710
June	3·825	3·560	1·720	2·440	·845	1·675	1·685	·755	1·045	2·685	1·505	2·390	1·385	2·750	·870
July	3·770	2·985	1·785	2·435	2·215	1·610	·255	2·425	1·400	7·355	2·980	4·520	3·765	2·375	2·430
August	4·440	·445	4·015	1·310	·625	1·105	1·405	1·015	2·540	2·285	2·425	2·545	4·510	3·520	·565
September	3·160	4·645	2·065	2·565	3·185	2·370	4·230	1·845	2·495	·880	1·175	·530	·740	3·025	1·195
October	·693	7·500	2·455	5·695	1·925	1·230	3·455	2·290	1·780	1·390	4·195	1·180	6·010	4·230	3·480
November	1·200	2·325	3·615	2·230	3·760	1·535	2·765	3·335	4·910	3·885	·830	1·960	2·615	2·420	2·185
December	·930	3·055	2·865	2·090	·610	2·305	1·175	4·410	1·500	1·480	1·390	·790	3·525	1·305	2·610
Total	30·890	30·565	25·665	26·490	24·150	19·770	26·615	26·955	22·960	27·735	25·285	23·610	30·545	25·135	19·775

Month.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	2·865	1·760	·610	1·770	·800	2·770	3·180	·820	·670	2·155	3·630	1·110	4·295	1·295	1·660
February	1·680	·290	·305	2·040	1·315	2·485	4·585	1·405	·810	1·510	3·050	·990	2·085	1·645	1·230
March	1·135	1·485	3·010	3·955	1·360	·765	·890	2·655	1·725	2·310	1·520	3·085	1·155	·950	2·905
April	1·825	1·525	·640	1·285	1·155	2·425	·860	2·065	·720	1·740	1·260	1·715	·570	3·820	2·520
May	1·370	·420	·145	1·610	2·985	1·725	1·455	1·220	2·500	3·890	2·440	1·060	1·445	1·920	2·015
June	2·480	·350	2·285	2·125	1·445	·860	2·820	1·515	3·980	7·200	·800	5·475	2·595	2·035	2·475
July	3·840	3·545	1·815	1·110	·825	·635	·980	1·500	1·220	4·290	1·260	·680	·700	·820	3·455
August	2·995	2·365	2·090	2·640	·980	·785	3·005	2·040	3·225	3·830	1·655	2·485	1·365	2·330	3·400
September	1·960	·530	7·000	2·655	·470	2·355	·795	1·165	1·105	2·010	1·215	2·105	1·565	·710	1·470
October	5·250	2·505	3·335	·620	2·955	2·385	1·805	2·860	1·440	5·275	1·885	1·115	3·765	3·645	2·535
November	4·300	4·035	1·520	1·035	3·185	4·520	2·260	·670	1·890	2·365	1·405	3·850	4·240	2·760	·755
December	1·710	2·305	3·285	3·110	2·925	1·660	2·625	4·020	1·380	2·160	2·435	·500	2·035	3·375	2·395
Total	31·410	21·115	26·040	23·955	20·400	23·370	25·260	21·935	20·665	38·735	22·555	24·170	25·815	25·305	26·815

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gauge, yet the amount of water percolating is not so much reduced by this larger amount of grass which has been grown as the author would have thought might have been the case. The luxurious growth of grass on the gravel gauge does exercise an influence on percolation. In the time of heavy rainfall, when the gauges are sensitive in the winter period and vegetation is dormant, the water passes quickly through the gravel gauge, but in summer when vegetation is active the result is different. In the summer months it will be seen that less percolation takes place through the gravel gauge between April and September than takes place through the chalk gauge. Table II. gives the monthly quantity of percolation that has taken place through the chalk gauge, and Table III. the monthly quantity of percolation that has passed through the gravel gauge. Table IV. shows the yearly quantity of rainfall, the percolation through the chalk and the gravel gauges, and the percentage of the rainfall passing through the percolating gauges, together with the weight of grass cut off the respective gauges each year, and the number of months every year when no percolation occurred.

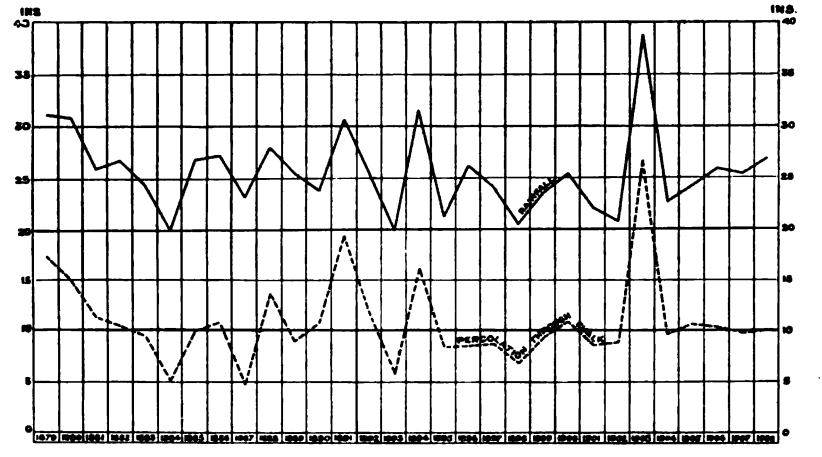


FIG. 1.—Rainfall and Percolation through Chalk—Yearly Totals.

It will be seen that on the average of 26 years' observations the weight of grass cut off the gravel gauge was 3·919 lbs. per annum, while off the chalk gauge 2·123 lbs. on the average was taken. These quantities varied greatly from year to year, the largest quantity having been grown in the year 1903, which had a very wet summer, when 7·979 lbs. were cut from the gravel gauge, and 3·566 lbs. from the chalk gauge. The least amount of grass, ·895 lb., was cut off the gravel gauge in 1887, and ·586 lb. off the chalk gauge in 1888.

From Table IV. it will be seen that in the 30 years the total average annual amount of percolation through the chalk gauge has been 10·84 ins., and through the gravel gauge 10·34 ins. The table also shows the percentage of rainfall that passed every year through the percolating gauges, which on the average with the chalk gauge was 42·60 per cent, and through the gravel gauge 40·63 per cent. The average yearly rainfall given in this table is 25·46 ins., so that the difference between the rainfall and

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TABLE II.—Percolation through Chalk Gauge at Croydon. Section cut out of Riddlesdown.

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	·9500	·9737	1·2231	1·1412	2·1940	1·6536	·2320	3·2512	3·1397	·5850	1·1274	1·9210	2·1570	·7159	1·6380
February	3·0975	2·6295	3·0900	·7839	4·4530	1·9570	2·6460	·8511	·1917	·6541	1·8558	1·0570	·6945	1·4430	3·0139
March	·7237	·3545	1·3676	·8294	·4041	1·3469	1·3741	·2709	·4844	2·4745	1·4346	1·6470	1·6122	1·0903	·7404
April	1·3508	·3562	·0183	·6641	·0877	·0018	·3715	·8364	·1890	1·2090	1·0489	·7304	·2847	·2024	...
May	1·4499	·0013	...	·4405	·6053	·0002	1·1456	1·7550	·0710	·0485	·6582	·6123	·3880	·0375	...
June	1·6150	...	...	·0004	...	...	·1455	·0601	·0148	·0012	·0798	·0018	·2214	...	...
July	2·3325	...	·0002	...	...	...	...	...	...	2·7962	·0004	2·5781	·0064	...	...
August	2·1833	...	...	...	·0002	·0002	...	...	...	1·3446	...	·0459	2·8255	·4360	...
September	1·3203	·2339	...	...	...	...	...	...	...	·0002	...	·1441	·4248	·6597	...
October	·6812	5·4865	...	2·8470	...	...	·2613	...	...	...	·4572	·0039	5·1967	3·3982	..
November	·4717	2·2320	2·4813	1·8060	·8780	...	2·5597	·9781	·0231	2·8480	1·0580	1·3074	2·1254	2·3960	...
December	1·0180	2·5666	3·0697	1·8070	·6988	...	1·1405	2·7710	·5629	1·6236	1·1420	·6680	3·2490	1·2365	·3357
Total	17·1939	14·8342	11·2502	10·3195	9·3211	4·9597	9·8762	10·7738	4·6766	13·5849	8·8623	10·7169	19·1856	11·6155	5·7280

Month.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	2·3918	1·4631	·6424	1·9111	1·1067	3·0269	3·1530	1·0103	·8350	2·1286	3·4088	·6780	4·1008	1·2363	1·2885
February	1·3904	·1575	·2091	1·9364	·5478	2·4769	3·7100	·7287	·4492	1·1495	3·3234	·5715	1·8151	1·2384	·7028
March	1·1246	1·1359	2·2335	2·9242	1·0588	·1733	·7732	2·4628	1·1807	1·7905	·8886	2·9434	·7281	·3442	2·2730
April	·0037	·4472	·1795	·4764	·1980	1·0868	·2423	1·9450	·2201	·4854	·2721	·5781	·1111	1·4513	1·3673
May	·0219	·0350	·0093	·1028	·7279	·0993	...	...	·4096	1·8723	·1195	·0159	...	·7152	·7923
June	·2958	·0009	·0057	·0053	·0271	·0025	...	...	2·3665	5·9531	·2551	1·8586	...	·2505	·0013
July	·2702	...	...	...	...	...	...	...	...	1·3009	...	...	...	·0002	·0041
August	·4769	·2177	·0779	...	...	...	...	...	...	2·1119	...	...	...	·0002	...
September	·2972	·0289	·7403	...	...	...	...	...	·3055	·4663	...	...	...	...	·4383
October	4·0746	·6373	1·1022	...	·0014	...	...	...	·3496	4·3434	...	...	...	...	·7880
November	4·3442	2·5086	·8594	...	·7404	1·4633	·5388	...	1·2938	2·3123	...	3·1745	2·6935	1·3520	·4958
December	1·3180	1·7716	2·3986	1·2527	2·3439	·9206	2·4000	2·4081	1·4108	2·5885	1·3017	·7849	·8525	3·1393	1·8819
Total	16·0093	8·4037	8·4579	8·6089	6·7520	9·2496	10·8173	8·5549	8·8208	26·5027	9·5692	10·6049	10·3011	9·7276	10·0333

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TABLE III.—PERCOLATION THROUGH GRAVEL GAUGE AT CROYDON. SECTION CUT OUT OF VALLEY, OLD TOWN, CROYDON.

MONTH.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	1·4297	·6742	1·2549	1·0045	1·7820	1·3891	1·3890	3·4766	3·1733	·5656	1·0171	2·2010	1·5170	·5128	1·0075
February	3·0675	2·6573	2·9950	·9073	4·0337	1·3756	2·5018	·5649	·2470	·6459	1·9116	·8617	·3106	1·2071	2·8475
March	·3900	·2183	1·0052	·4975	·0552	1·0023	1·1370	·4261	·8646	2·5051	1·5396	1·7768	1·4423	1·0034	·6095
April	1·1058	·1370	·0022	...	·0092	...	·1247	·4950	·3467	·8691	·8902	·7781	...	·0720	·0135
May	1·1128	·0413	...	·0004	·2860	...	·2319	1·2163	·0391	·0612	·1791	·5199	·0295	·0050	·0121
June	1·1754	·0016	...	·0008	·0002	...	·0493	·0452	·0628	·0380	·0758	·0748	·0022	...	...
July	1·9500	...	·0057	...	·0017	...	·0006	·0094	·0353	3·0520	·0740	1·9501	·0114	·0019	...
August	2·1026	...	·0643	...	...	·0038	...,	·0010	·0140	1·0513	·0153	·0124	2·1936	·2120	...
September	1·2654	·3216	...	·0039	...	...	·0114	·1178	·4055	·0136	·0002	·0034	·1670	·5376	...
October	·4964	4·7598	·3078	2·2884	·0417	...	2·0619	...	·5693	·0015	1·2595	·0001	4·8197	3·3256	·0379
November	·6008	2·1720	2·7889	1·1222	2·4420	...	2·6126	2·2750	4·1681	2·3816	·6960	1·0620	2·1739	2·1630	·5678
December	1·1984	2·6689	2·8888	1·5060	·4680	1·8222	1·1143	3·1647	1·3843	1·4464	1·2170	·6185	3·2160	1·2150	2·2003
Total . . .	15·8948	13·6520	11·3128	7·3310	9·1197	5·5930	11·2345	11·7920	11·3100	12·6313	8·8754	9·8588	15·8832	10·2554	7·2961

MONTH.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	2·3186	1·4114	·5888	1·7558	1·0429	2·8843	3·0785	·9958	·7137	1·9276	3·2969	·5291	4·0316	1·2154	1·1528
February	1·1329	·1073	·1985	1·8652	·4644	2·3482	4·0429	·6871	·3697	·9528	3·1743	·6688	1·6652	1·1588	·4807
March	·7166	1·1468	2·0858	2·7302	·9108	·1261	·6771	2·3727	1·0730	1·6601	·7537	2·6928	·5350	·2371	1·8462
April	...	·2752	·1490	·4151	·0832	·8378	·1798	1·6877	·1264	·3302	·1779	·6218	·0550	1·2144	·6826
May	...	·0970	·0006	·0060	...	·0330	...	...	...	1·4834	·0273	·0309	·0823	·3618	·3113
June	·0003	·0008	·0002	...	...	...	...	...	·9581	5·2500	...	·8386	·6029	·0258	·0630
July	·0003	·0748	·0502	·0042	...	...	...	...	...	1·3186	...	·0495	·0528	...	...
August	·0004	·0006	·0380	·0600	...	...	...	...	...	1·7101	...	·1535	·3025	...	...
September	...	·0284	·6776	·0100	...	·0135	...	...	...	·0481	...	·0179	·0070	·0013	...
October	2·7041	·6338	1·5975	...	...	...	...	...	...	3·4761	...	...	·3127	·0063	...
November	4·6400	2·9443	1·0236	...	1·2450	3·2828	·3419	...	...	2·2734	·0004	2·8255	3·9004	·7310	...
December	1·3568	2·0413	2·7829	2·0024	2·4141	·9962	2·2350	3·3496	1·1357	2·4108	2·1289	·6541	1·1163	2·9782	1·2420
Total . . .	12·8700	8·7617	9·1927	8·8489	6·1604	10·5219	10·5552	9·0929	4·3766	22·8412	9·5594	9·0825	12·6637	7·9301	5·7786

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TABLE IV.—PERCOLATION RECORDS TAKEN AT CROYDON.

YEAR.	Rainfall.	Chalk Percolation Gauge.					Gravel Percolation Gauge.				
		Percolation.	Percentage of Rainfall Percolating.	No. of Months no Percolation.	Grass cut off. Times cut.	Grass cut off. Weight.	Percolation.	Percentage of Rainfall Percolating.	No. of Months no Percolation.	Grass cut off. Times cut.	Grass cut off. Weight.
	ins.	ins.	%		No.	lbs.	ins.	%		No.	lbs.
1879	30·890	17·1939	55·661	...	Not r	ecorded	15·8948	51·456	...	Not r	ecorded
1880	30·565	14·8342	48·533	3	...	...	13·6520	44·665	2	...	...
1881	25·665	11·2502	43·834	5	...	...	11·3128	44·078	3	...	...
1882	26·490	10·3195	38·956	3	...	...	7·3310	27·674	3	...	...
1883	24·150	9·3211	38·596	4	1	1·188	9·1197	37·762	2	2	2·876
1884	19·770	4·9597	25·087	6	1	·719	5·5930	28·290	7	2	2·906
1885	26·615	9·8762	37·107	3	1	·703	11·2345	42·211	1	2	3·047
1886	26·955	10·7738	39·969	4	1	1·300	11·7920	43·747	1	2	3·656
1887	22·960	4·6766	20·368	4	1	·663	11·3109	49·259	...	1	·895
1888	27·735	13·5849	48·981	1	1	·586	12·6313	45·542	...	2	3·176
1889	25·285	8·8623	35·049	2	2	3·368	8·8754	35·101	...	2	3·548
1890	23·610	10·7169	45·391	...	2	1·672	9·8588	41·757	...	2	5·063
1891	30·545	19·1856	62·810	...	2	2·622	15·8832	51·999	1	2	5·654
1892	25·135	11·6155	46·212	2	2	3·485	10·2554	40·801	1	2	5·844
1893	19·775	5·7280	28·965	8	2	2·437	7·2961	36·895	4	2	1·672
1894	31·410	16·0093	50·968	...	2	3·258	12·8700	40·974	3	2	5·879
1895	21·115	8·4037	39·799	1	2	2·771	8·7617	41·495	...	2	3·057
1896	26·040	8·4579	32·480	1	2	2·938	9·1927	35·302	...	2	4·270
1897	23·955	8·6089	35·937	5	2	2·180	8·8489	36·939	3	2	4·471
1898	20·400	6·7520	33·098	3	2	2·216	6·1604	30·198	6	2	4·304
1899	23·370	9·2496	39·578	4	2	2·166	10·5219	45·023	4	2	2·958
1900	25·260	10·8173	42·823	6	2	2·668	10·5552	41·786	6	2	4·004
1901	21·935	8·5549	39·001	7	2	2·169	9·0929	41·453	7	2	3·641
1902	20·665	8·8208	42·684	2	2	2·356	4·3766	21·178	6	2	4·680
1903	38·735	26·5027	68·420	...	2	3·566	22·8412	58·968	...	2	7·979
1904	22·555	9·5692	42·426	5	2	3·360	9·5594	42·382	5	2	4·846
1905	24·170	10·6049	43·876	4	2	1·813	9·0825	37·577	1	2	3·988
1906	25·815	10·3011	39·903	6	2	2·095	12·6637	49·055	...	2	2·900
1907	25·305	9·7276	38·441	2	1	1·024	7·9301	31·338	2	1	2·418
1908	26·815	10·0333	37·417	1	2	1·885	5·7786	21·550	5	2	4·170
Totals	763·690	325·3116	...	92	45	55·208	310·2758	...	73	50	101·902
Average, 26 years, 1883 to 1908	25·003	10·4505 = 41·797		3·12	1·73	lbs. 2·123 per yard = 4·587 tons per acre.	10·0802 = 40·316		2·50	1·92	lbs. 3·919 per yard = 8·468 tons per acre.
Average, 30 years, 1879 to 1908	25·456	10·8437 = 42·598		3·07	...		10·3425 = 40·629		2·43	...	

percolation has been 14·62 ins. in the case of the chalk gauge and 15·12 ins. in the case of the gravel gauge.

Some small amount of the water measured as passing through the percolating gauges was due to condensation; this has especially been the case with the gravel percolator.

It will be seen that in the 30 years, or 360 months, for 92 months there was no percolation through the chalk gauge, but there were only 73

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months in the same period when there was no percolation through the gravel gauge.

It should be noted that the differences between rainfall and percolation through a percolating gauge do not represent the full amount of evaporation which takes place from the ground, for the simple reason that for a part

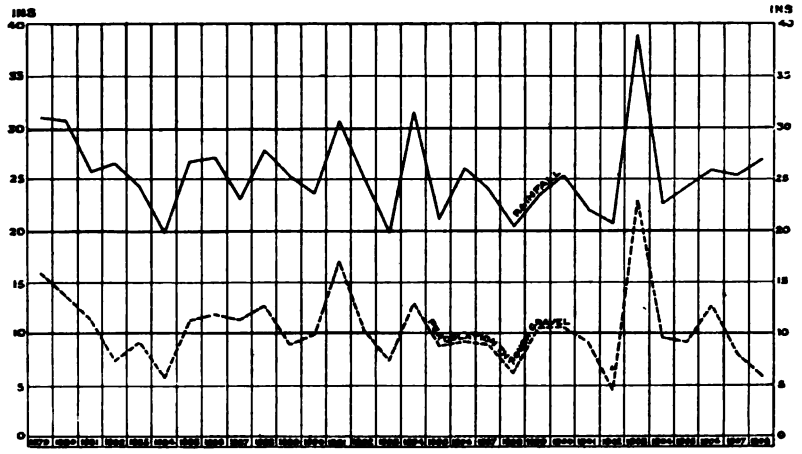


FIG. 2.—Rainfall and Percolation through Gravel—Yearly Totals.

of the year the percolating gauge may be nearly dry, there being no water in the subsoil the same as found in nature. Consequently the percolating gauge is not the true measure of the losses by evaporation which took place in nature from the ground, as there is no doubt that water after penetrating the ground, owing to its temperature, continues to give off vapour and loses a certain volume, as was shown by the author in his address before this Society on January 27, 1892.[1]

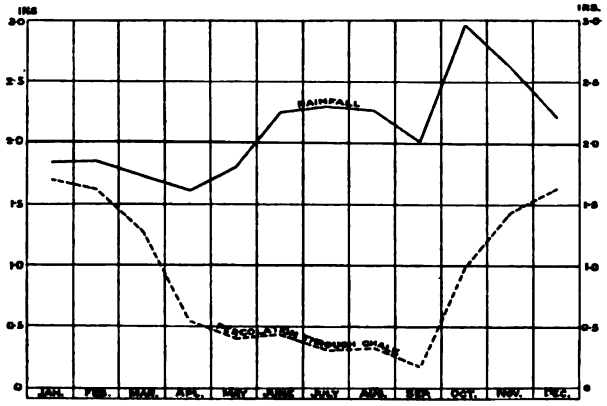


FIG. 3.—Rainfall and Percolation through Chalk—Monthly Means.

The largest amount of percolation, as a rule, takes place in the six months from October to March. There is, however, an exception to this

[1] *Quarterly Journal*, vol. 18, p. 53.

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in the year 1903, when the largest percolation occurred in the month of June; 5·25 ins. passed through the gravel gauge and 5·95 ins. through the chalk gauge in that month.

What has been observed with reference to the quantity of water passing through the percolating gauges shows that the rate of percolation is governed by the rate of rainfall; that when once the gauges have become sensitive by being thoroughly wetted, the rate at which rain percolates depends entirely on the quantity of rain immediately falling. This will be seen from the following notes of the large percolations which have taken place between 1879 and the present time.

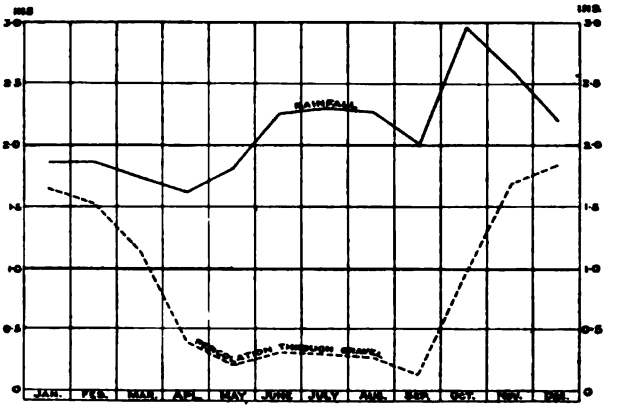


FIG. 4.—Rainfall and Percolation through Gravel—Monthly Means.

May 28, 1879.—This date was late in the year for heavy percolation to take place. Moreover the year 1879 was a cold and wet year. 0·80 in. passed through both gauges on this day out of a rainfall of 1·51 ins. which fell in a short time.

October 9, 1880.—·90 in. passed through the chalk gauge and ·80 in. passed through the gravel gauge out of 2·05 ins. of rain which fell on this day.

October 28, 1882.—1·01 ins. passed through the chalk gauge, 1·00 in. through the gravel gauge. Percolation only commenced a week before this large amount was passed. The rainfall was ·21 in. on the 26th, ·92 in. on 27th, and ·51 in. on 28th. Of the 1·01 ins. percolating ·8 in. of it percolated in twelve hours between 9 a.m. and 9 p.m.

February 10, 1883.—·859 in. percolated through the chalk gauge and ·860 in. through the gravel gauge. On the 9th, ·574 in. percolated through the chalk gauge and ·563 in. through the gravel gauge. The rainfall previously had been ·65 in. on the 8th, ·49 in. on the 9th, and ·66 in. on the 10th.

January 26, 1884.—·735 in. percolated through the chalk gauge and ·740 in. through the gravel gauge. Rainfall was ·86 in. on that day and ·30 in. the day before.

November 3, 1887.—·715 in. percolated through the gravel gauge and nothing passed through the chalk gauge. The previous rainfall had been ·41 in. on the 1st, ·60 in. on the 2nd, and ·745 in. on the 3rd. During the whole of this year, 1887, the gravel gauge passed water every month,

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TABLE V.—Evaporation, Floating Evaporator, at Croydon.

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	·000	·095	·177	·250	·340	·400	·220	·290	·030	·080	·040	·660	·450	·305	·230
February	·165	·300	·298	·425	·405	·570	·355	·200	·355	·375	·235	·430	·375	·590	·340
March	·825	1·440	1·185	1·440	·990	1·355	1·115	·640	·750	·560	·660	1·280	1·620	1·055	1·200
April	1·420	2·370	2·575	2·270	2·140	1·995	2·310	2·065	2·225	1·655	1·535	1·850	1·775	2·015	2·435
May	2·200	3·480	3·655	3·665	3·280	3·955	2·700	2·910	2·320	3·350	2·695	3·510	2·255	3·160	2·780
June	2·780	3·040	4·000	2·990	3·885	3·035	4·145	3·675	4·275	2·715	3·605	2·840	3·315	3·690	3·350
July	2·235	3·710	4·675	3·545	3·815	4·000	4·825	3·970	4·960	2·095	3·370	3·120	3·095	3·105	2·800
August	2·430	2·800	2·995	2·870	3·635	4·315	3·235	2·545	3·955	2·530	2·735	2·745	2·590	2·740	2·495
September	1·710	2·130	1·215	1·495	1·430	1·650	1·615	1·940	1·745	1·110	1·705	1·510	1·580	1·535	1·425
October	·890	·745	·970	·740	·875	·930	·935	·705	·815	·455	·810	1·315	1·135	1·150	·580
November	·360	·345	·505	·615	·365	·295	·255	·335	·280	·510	·505	·880	·590	·505	·120
December	·000	·320	·155	·085	·380	·355	·065	·065	·165	·090	·256	·230	·535	·270	·045
Total	15·015	20·775	22·405	20·390	21·540	22·855	21·775	19·340	21·875	15·525	18·151	20·370	19·315	20·120	17·800

Month.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	·070	·185	·285	·085	·310	·370	·195	·110	·235	·425	·110	·350	·365	·500	·225
February	·290	·280	·320	·270	·615	·375	·120	·215	·115	·430	·350	·390	·365	·365	·415
March	·745	·740	·795	·945	·730	·725	·740	·655	·865	1·010	·620	·745	·645	1·290	·730
April	1·385	1·375	1·480	1·555	1·665	1·485	1·580	1·745	1·750	1·650	1·560	1·345	1·930	1·650	1·455
May	2·000	2·570	3·220	3·010	1·995	2·295	2·165	2·450	1·800	2·170	1·760	2·690	1·775	2·570	2·545
June	2·320	2·950	3·195	2·615	2·215	3·340	2·510	3·065	2·630	2·770	2·720	2·375	2·655	3·125	3·655
July	2·370	2·745	3·695	3·240	2·925	3·735	3·380	3·180	2·860	2·640	3·320	2·980	2·700	2·870	3·175
August	1·635	1·895	1·840	2·670	2·690	3·345	2·375	2·570	1·775	2·000	2·385	2·325	2·345	2·960	2·930
September	1·090	1·200	·980	1·445	1·810	1·785	1·455	1·565	1·445	1·380	1·315	1·155	1·715	1·870	1·615
October	·370	·690	·555	·795	·785	·725	·895	·810	·730	·855	·675	·625	·710	1·415	1·075
November	·310	·405	·265	·420	·445	·510	·450	·290	·390	·485	·365	·280	·490	·630	·570
December	·110	·250	·055	·220	·305	·185	·295	·030	·340	·205	·255	·125	·255	·865	·485
Total	12·695	15·285	16·685	17·270	16·490	18·875	16·160	16·685	14·935	16·020	15·435	15·385	15·950	20·110	18·875

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while the chalk gauge for some time ceased to pass water. The chalk gauge in November 1887 only passed ·023 in., while the gravel gauge passed 4·168 ins.

August 1, 1888.—Percolation through the chalk gauge was ·795 in. and through the gravel gauge ·741 in. The percolation had been ·691 in. on the 30th, ·260 in. on 31st of July through chalk gauge, and ·756 in. on 30th and ·325 in. on 31st July through the gravel gauge. The previous rainfall had been 1·095 ins. on 30th and ·635 in. on 31st July, and ·615 in. on 1st August.

October 22, 1891.—·823 in. percolated through the chalk gauge and ·735 in. through the gravel gauge. The rainfall immediately preceding had been ·595 in. on the 21st and ·485 in. on the 22nd.

October 30, 1892.—·850 in. percolated through the chalk gauge and ·900 in. through the gravel gauge. There was 1·37 ins. of rain on the same day.

July 10, 1894.—As an instance of heavy rainfall failing to affect the percolating gauges, on this day 1·85 ins. of rain fell and there was no percolation, but two days subsequently there was a small amount of percolation.

October 30, 1894.—1·062 ins. percolated through the chalk gauge and 1·067 ins. through the gravel gauge. The rainfall on the 30th was 1·47 ins., and there had been heavy rain previously.

November 12, 1894.—1·182 ins. percolated through the chalk gauge. The rainfall on that day was 1·02 ins., on the 11th ·395 in., and on the 10th ·24 in. This is the largest amount of percolation through the chalk gauge that has taken place in a single day in the thirty years' observations.

December 7, 1898.—Percolation 1·050 ins. through the chalk gauge and 1·080 ins. through the gravel gauge. On the 7th ·40 in. of rain fell, and on the 6th there was 1·09 ins. of rain.

May 30, 1903.—1·85 ins. of rain caused ·50 in. of percolation on the same day through the chalk gauge and ·43 in. through the gravel gauge.

June 11, 1903.—The heavy rains of June of this year caused a considerable amount of percolation at an unusual season. On the above date 1·120 ins. percolated through the chalk gauge and 1·110 ins. through the gravel gauge. On the 10th 1·72 ins. of rain fell, and on the 11th there was ·74 in. of rain.

June 15, 1903.—1·150 ins. percolated through the chalk gauge and 1·210 ins. percolated through the gravel gauge. This is the largest amount of percolation through the gravel gauge that has taken place in a single day in the whole period of observation. The rainfall preceding this percolation was 1·09 ins. on 13th, ·94 in. on 14th, and ·75 in. on the 15th. The rainfall of June 1903 was 7·20 ins., and it all fell on 12 days, and in 119·5 hours.

October 12, 1903.—·820 in. percolated through the chalk gauge and ·780 in. through the gravel gauge. The rainfall was 1·00 in. on the 11th and ·54 in. on the 12th.

October 26, 1903.—·770 in. percolated through the chalk gauge and ·750 in. through the gravel gauge. The rainfall on the 26th was ·84 in.

November 27, 1903.—·610 in. percolated through the chalk gauge and ·670 in. through the gravel gauge, the rainfall on that day being 1·30 ins.

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January 30, 1904.—·860 in. percolated through the chalk gauge and ·810 in. through the gravel gauge. The rainfall was ·70 in. on the 30th and ·36 in. on the 29th.

June 10, 1905.—·780 in. percolated through the chalk gauge and ·380 in. through the gravel gauge. There was 1·45 ins. of rain in the day.

No particularly large amount of percolation has occurred since the last date. From the examples given it will be seen that at times a very large percentage of the rain falling at once passes into the ground.

The first water passing through both the chalk and the gravel percolation gauges the author has had repeatedly analysed. The water of the chalk gauge has been found to contain, immediately after percolation commenced, from 21·28 grains to 25·76 grains per gallon of total solids, and to vary in hardness from 9° to 15°. The total solids in the chalk water of the Croydon waterworks wells have been found to vary from 20 to 26 grains per gallon, and its hardness from 12°·9 to 16°·8.

The first water passing the gravel gauge has been found to contain from 29·40 to 59·36 grains per gallon of total solids, and to vary in hardness from 16° to 22°, showing that the larger amount of solid matter contained in well waters is derived from the first three feet in depth.

Evaporation.

At the same time and place as the percolating experiments, experiments upon evaporation from a water surface were carried out by the author. A portion of these results for the thirteen years 1879-1891 [1] has already been published by this Society, but the whole series are now given for the last thirty years, as it is desirable that all the observations should be considered together.

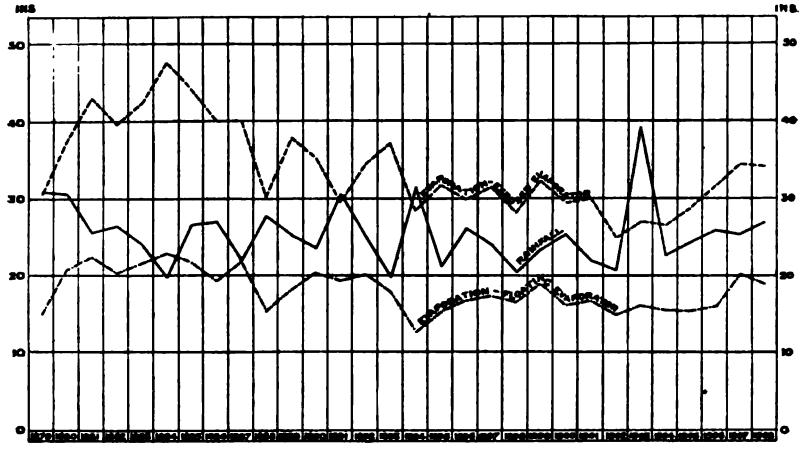


Fig. 5.—Rainfall and Evaporation from Exposed and Floating Evaporators—Yearly Totals.

The standard form of evaporator used for determining the evaporation was a floating copper vessel 1 ft. in diameter, supported by a life-buoy ring connected by four arms with the evaporating vessel, the whole

[1] *Quarterly Journal*, vol. 18, p. 53.

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being floated in a tank 4 ft. internal diameter containing about 3 ft. depth of water.

The author has also at the same time and place carried on evaporation experiments with the old form of evaporator thoroughly exposed to the air, and standing in the open on an iron pedestal, so as to be able to compare the evaporation from the floating evaporator with that which was formerly used for the purpose of determining the amount of evaporation taking place from a water surface. The observations have been taken daily, and the temperature of the water in the floating evaporator has also been taken every day at 9 a.m. and sometimes at other periods of the day.

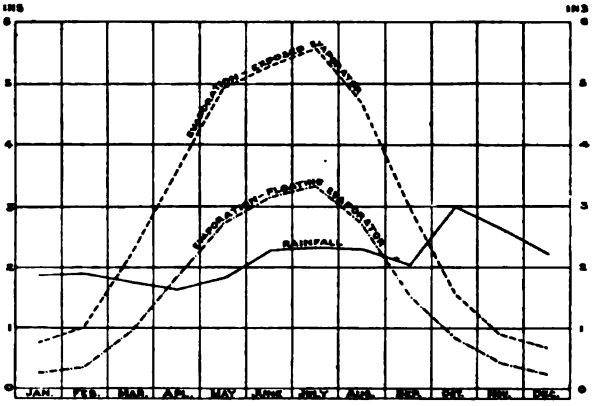


FIG. 6.—Rainfall and Evaporation from Exposed and Floating Evaporators—Monthly Means.

The quality of the water used in evaporation experiments has been shown to affect the amount of evaporation, being very much less with sea water than with fresh water. In the evaporation experiments conducted by the author, the evaporators have always been filled with rain water.

Table V. gives the monthly totals of evaporation taking place from the floating evaporator.

Table VI. shows the monthly amount of condensation taking place in the floating evaporator.

Table VII. gives the monthly totals of evaporation taking place from a fully exposed evaporator in the open air.

Table VIII. is a table which gives the annual amount of rain, evaporation, condensation, the temperature of the water of the floating evaporator and the temperature of the dew-point at 9 a.m. each year, and the number of days each year when ·20 in. or more of water was evaporated from the floating evaporator.

The average amount of evaporation taking place for the last 30 years from the floating evaporator, as will be seen by the accompanying tables, was 18·137 ins. The average annual amount of condensation measured in these 30 years has been ·359 in., and the evaporation taking place from the fully exposed evaporator 33·850 ins.

It was pointed out in the author's address of 1892 that in all probability there is an error even in the floating evaporator which would

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TABLE VI.—Condensation in Floating Evaporator at Croydon.

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	·020	·020	·010	·120	·085	·070	·150	·020	·045	·070	·115	·055	...	...	·020
February	·055	·070	·045	·030	·070	·015	·055	·050	·020	...	·020	...	·030	·050	·070
March	·005	·010	·005	·005	...	·030	...	·005	·005	·030	·055	...	·015	...	...
April	...	...	...	...	...	...	·005	...	...	...	...	...	...	...	...
May	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
June	·075	...	...	...	...	...	...	...	...	...	...	...	...	...	...
July	...	...	...	...	...	...	...	...	...	...	...	...	...	...	·010
August	·025	...	...	...	...	...	...	...	...	...	...	...	...	...	...
September	...	...	...	...	...	...	...	...	...	...	...	...	...	...	·030
October	·020	·185	·035	·050	·020	...	·040	·065	...	·020	·015	·005	·025	...	·090
November	·025	·100	·040	·025	·025	·025	·035	·040	·050	·050	·030	·055	·045	·060	·570
December	·360	·075	·110	·155	·030	·110	·130	·040	·060	·145	·040	...	·210	·060	·505
Total	·585	·460	·245	·385	·230	·250	·415	·220	·180	·315	·275	·115	·325	·170	1·295

Month.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	·180	·035	·055	·035	·020	·030	·240	·070	·020	·010	·170	...	·020	...	·140
February	·115	...	·065	·045	...	·030	·335	·040	·040	·020	·010	·020	·050	·015	·015
March	·040	...	·060	·020	·050	...	...	·060	·010	·020	...	·030	·030	·010	·045
April	...	...	...	...	·010	...	...	·010	...	...	...	...	...	·010	·085
May	...	...	·005	...	...	...	...	...	...	·010	...	...	·020	...	...
June	...	...	...	...	...	...	...	...	...	...	...	·010	...	...	...
July	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
August	...	...	·010	...	...	...	...	...	...	·020	...	...	...	...	...
September	...	·010	...	...	...	...	...	...	...	·010	...	...	...	...	·005
October	·270	·105	·020	·025	·010	·010	·050	...	·010	...	...	·020	·025	·010	·010
November	·115	·180	·020	·065	...	...	·010	·030	·120	...	·010	·110	·010	·060	·055
December	·375	·045	·195	·150	·020	·025	·020	·224	...	·075	·040	·015	...	·050	·305
Total	1·095	·375	·430	·340	·110	·095	·655	·434	·200	·165	·230	·205	·155	·155	·660

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TABLE VII.—Evaporation, Exposed Evaporator, at Croydon.

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	1·000	·745	1·210	·745	1·055	1·335	·715	·555	·325	·620	·540	1·455	·810	·800	·500
February	1·250	1·890	·690	1·265	1·340	1·675	1·315	·450	1·200	·580	1·000	1·230	·910	·980	·940
March	1·080	3·140	3·620	3·255	2·015	3·350	3·035	1·490	1·715	1·450	2·135	3·050	2·490	2·455	2·840
April	2·370	3·995	4·015	4·220	4·570	3·645	5·485	4·165	4·315	3·205	3·655	4·720	3·250	4·115	5·060
May	4·795	5·630	6·800	6·355	5·810	7·185	5·020	5·810	3·940	6·050	6·045	5·620	3·960	5·970	5·150
June	4·635	4·670	6·350	4·890	6·665	5·515	7·415	6·445	6·955	4·480	6·455	4·100	4·805	5·600	6·310
July	4·660	4·475	8·335	5·835	6·195	6·985	8·565	7·230	8·390	3·745	5·810	4·600	4·155	4·885	5·100
August	4·930	4·535	5·095	4·910	6·545	8·985	5·725	5·495	7·135	4·295	5·425	3·785	3·170	4·290	5·165
September	3·340	4·775	2·315	3·050	3·430	4·225	3·625	4·510	3·205	2·530	3·715	3·080	2·585	2·445	2·955
October	1·365	1·220	2·075	1·935	2·165	2·360	1·775	2·320	1·465	1·310	1·615	1·960	1·565	1·490	1·830
November	·660	1·195	1·625	1·920	1·250	1·070	·770	·935	·720	1·320	·730	·945	·865	·770	·835
December	·520	1·065	·805	1·040	1·175	1·200	·580	·515	·590	·545	·630	·510	·970	·545	·425
Total	30·605	37·335	42·935	39·420	42·215	47·530	44·025	39·920	39·955	30·130	37·755	35·055	29·535	34·345	37·110

Month.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	·545	·560	·645	·175	·640	·740	·730	·790	·715	·995	·420	·775	·915	·735	·500
February	1·140	·655	·765	·900	1·235	1·035	·565	·415	·455	1·020	·640	1·220	1·015	·955	1·090
March	2·425	1·640	1·705	2·060	1·700	1·845	1·780	1·470	1·705	2·260	1·260	2·045	1·815	3·230	1·610
April	3·375	2·955	2·730	2·825	3·315	2·435	3·240	3·525	2·970	2·570	2·840	2·565	4·010	2·880	2·430
May	3·660	5·120	5·500	5·360	2·895	3·805	4·095	5·090	2·890	3·840	2·950	5·190	3·685	4·260	4·305
June	4·510	5·860	5·730	4·905	3·515	5·640	4·280	4·825	4·550	4·280	4·260	4·225	4·945	4·825	6·175
July	4·790	4·825	6·455	6·080	4·315	5·975	5·730	4·930	4·360	4·130	5·560	4·950	5·000	4·840	5·575
August	3·025	3·975	2·945	4·550	4·500	5·755	3·355	4·060	2·645	3·160	4·205	3·545	4·335	5·060	5·140
September	1·880	3·460	1·500	2·195	3·410	2·675	2·605	2·285	2·345	2·260	1·975	1·825	2·995	3·320	3·410
October	1·290	1·060	·805	1·205	1·315	1·045	1·810	1·210	·960	1·345	1·055	1·040	1·555	2·215	2·255
November	·925	·780	·540	·620	·545	·810	·610	·870	·640	·705	·595	·760	·820	·950	1·015
December	·740	·700	·455	·505	·685	·440	·645	·485	·610	·395	·650	·450	·425	1·215	·595
Total	28·305	31·590	29·775	31·380	28·070	32·200	29·445	29·955	24·845	26·960	26·410	28·590	31·515	34·485	34·100

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not occur possibly in nature, due to the water being drawn up the sides of the evaporator by capillarity, and so producing a larger amount of evaporation than really occurs in nature. On the other hand, there is an error due to the checking of the evaporators by the rain-gauge, as the rain-gauge does not record that portion of water which is used in wetting the surface of the gauge, but which is measured on the surface of the water of the evaporator.

TABLE VIII.—Evaporation Records taken at Croydon.

Year.	Rainfall.	Evaporation, Floating Evaporator.	Number of days with ·20 or more Evaporating.	Condensation.	Evaporation, Exposed Evaporator.	Temperatures at 9 a.m.	
						Water, Floating Evaporator.	Dew-point.
	ins.	ins.		ins.	ins.	°	°
1879	30·890	15·015	nil	·585	30·605	46·14	42·80
1880	30·565	20·775	3	·460	37·335	49·14	44·18
1881	25·665	22·405	13	·245	42·935	48·63	42·99
1882	26·490	20·390	1	·385	39·420	49·37	44·68
1883	24·150	21·540	7	·230	42·215	49·27	43·55
1884	19·770	22·855	7	·250	47·530	50·01	44·63
1885	26·615	21·775	10	·415	44·025	48·09	42·41
1886	26·955	19·340	3	·220	39·920	48·79	43·09
1887	22·960	21·875	16	·180	39·955	47·75	41·29
1888	27·735	15·525	2	·315	30·130	47·91	42·61
1889	25·285	18·151	3	·275	37·755	49·20	43·99
1890	23·610	20·370	1	·115	35·055	47·88	43·44
1891	30·545	19·315	nil	·325	29·535	47·43	43·66
1892	25·135	20·120	4	·170	34·345	47·71	42·02
1893	19·775	17·800	3	1·295	37·110	51·52	44·65
1894	31·410	12·695	nil	1·095	28·305	51·26	44·50
1895	21·115	15·285	1	·375	31·590	50·38	43·50
1896	26·040	16·685	2	·430	29·775	51·09	44·47
1897	23·955	17·270	2	·340	31·380	51·57	44·72
1898	20·400	16·490	nil	·110	28·070	51·19	45·57
1899	23·370	18·875	2	·095	32·200	50·30	44·47
1900	25·260	16·160	nil	·655	29·445	50·64	44·73
1901	21·935	16·685	4	·434	29·955	49·29	43·44
1902	20·665	14·935	nil	·200	24·845	49·33	43·76
1903	38·735	16·020	1	·165	26·960	50·55	45·15
1904	22·555	15·435	1	·230	26·410	49·72	44·33
1905	24·170	15·385	nil	·205	28·590	49·47	44·15
1906	25·815	15·950	1	·155	31·515	50·43	44·31
1907	25·305	20·110	nil	·155	34·485	50·38	43·92
1908	26·815	18·875	5	·660	34·100	50·62	45·06
Totals	763·690	544·106	92	10·769	1015·495	1485·06	1316·07
Average 30 years	25·456	18·137	3·07	·3589	33·850	49·50	43·87

Upon mature consideration, having regard to both these errors, the author is of opinion that one error will balance the other, and that the amount of evaporation given by the floating evaporator correctly represents what actually takes place from a water surface. The author may say, in confirmation of his opinion, that the actual result of evaporation differs but very little from the actual amount of water falling as rain, and flowing off from the chalk drainage area immediately adjoining Croydon known as the drainage area to the Croydon branch of the River Wandle.

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It will be observed from Table VIII. that in the 30 years of observation ·2 in. or more of the water was evaporated in one day on 92 out of 10,957 days, or ·84 per cent of the whole number of days. With regard to large evaporations there are two days only when as much as ·29 in. was evaporated, and one day when ·295 in. was evaporated.

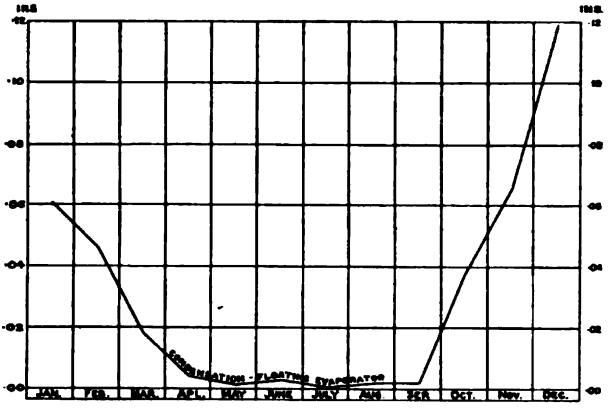


FIG. 7.—Condensation by Floating Evaporator—Monthly Means.

June 4, 1881.—·29 in. water evaporated. The horizontal movement of the air at Greenwich on this day was 300 miles; temperature of the dew-point 9 a.m. 52°·0, water 66°·5, air at 9 a.m. 69°·2; maximum day temperature in shade, 79°·3; tensional difference 9 a.m.—water ·650 in., dew-point ·388 in. = ·262 in. No rain.

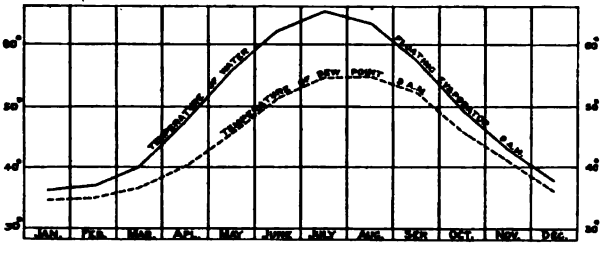


FIG. 8.—Temperature of the Dew-point, and Temperature of the Water in the Floating Evaporator—Monthly Means.

June 21, 1887.—·29 in. evaporated. The horizontal movement of the air at Greenwich this day was 362 miles; temperature of dew-point 9 a.m. 47°·1; temperature—water 65°·2, air 9 a.m. 63°·5; maximum day temperature in shade, 72°·1; tensional difference—water ·622 in., dew-point ·324 in. = ·298 in. No rain.

June 4, 1908.—·295 in. water recorded as evaporated. Temperature of dew-point 9 a.m. 62°·9. The mean of the maximum and minimum dew-point for this day was 60°·4. The horizontal movement of the air at Greenwich this day was 268 miles; temperature of water 9 a.m. 69°·4; temperature of air 9 a.m. 69°·5; maximum temperature of day

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in shade, 84°·2; tensional difference—water ·718 in., dew-point ·574 in. = ·144 in. Heavy rain and hail: 1·235 ins. fell in 1·35 hours.

With reference to the last observations, the author has every reason to believe that the whole of the loss was not due to true evaporation, but in all probability was due to the exceptionally heavy rain, and that a certain amount of rain may have splashed out of the evaporator, which would account for this large amount supposed to have been evaporated on that day.

As a rule the largest amount of evaporation takes place in the month of July, and the average of these 30 years was 3·305 ins. evaporated in this month. The month in the whole 30 years which had the greatest amount of evaporation was July 1887, when 4·96 ins. were evaporated. The month of least evaporation is December. On the average ·225 in. was evaporated, but in December 1879 there was no evaporation whatever.

Condensation.

In the course of these experiments on evaporation there have been periods when what has been termed negative evaporation has taken place —really condensation—and when there is a gain in the evaporators. All these periods of condensation have been kept separate and distinct from the days when evaporation occurred. As a rule condensation takes place after any sudden change of temperature from cold to warm, the moisture in the warm air condensing on the cold surface of the water. This often happens after a frost and during the period of rapid thaw when ice may still be floating on the surface of the water, and the air is warm and full of moisture. Hence condensation takes place in the winter months. On the average the largest amount of condensation has been recorded in December and the least in July. The results of condensation are given in Tables VI. and VIII., and show that the average yearly condensation is ·359 in. The greatest yearly condensation was 1·295 ins., which occurred in 1893, and the least yearly condensation was ·095 in., which occurred in the year 1899. The greatest monthly condensation recorded was ·570 in. in November 1893, and there are several months in every year when no condensation takes place.

The largest daily amount of condensation which has been recorded was ·08 in. on December 6, 1903. There was also the same amount of condensation recorded on November 16, 1893, but on that occasion there had been rainfall, and no doubt some of these condensations are the result of rain, that is, more rain being recorded on the surface of the evaporator than would be recorded by the rain-gauge, owing to the loss by adhesion of rain to the gauge; hence many of the records of condensation occur in the time of rain.

In Table IX. have been brought together the average monthly observations of the 30 years of rainfall, percolation, evaporation, and condensation; the temperature of the water of the floating evaporator at 9 a.m. and the temperature of the dew-point at 9 a.m. are also given.

There are some peculiarities with regard to percolation which show the influence of vegetation upon percolation. For example, it will be seen from the diagram that in 1891 the rainfall was 30·545 ins., and the percolation through the chalk gauge in that year was 19·1856 ins., the

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TABLE IX.—Monthly Average Rainfall, Percolation, Evaporation, and Condensation at Croydon for the 30 Years 1879 to 1908.

Month.	Rainfall.	Percolation, Chalk.	Percolation, Gravel.	Evaporation, Floating Evaporator.	Condensation, Floating Evaporator.	Evaporation, Exposed Evaporator.	Temperature of Water, Floating Evaporator, at 9 a.m.	Temperature of Dew-point at 9 a.m.
	ins.	ins.	ins.	ins.	ins.	ins.	°	°
January .	1·849	1·7095	1·6446	·246	·0608	·743	36·15	34·45
February .	1·854	1·6275	1·5150	·344	·0460	·994	36·86	34·81
March . .	1·733	1·2730	1·1346	·936	·0180	2·189	39·88	36·53
April . .	1·616	·5472	·3893	1·808	·0040	3·515	47·34	40·02
May . .	1·806	·4045	·2056	2·698	·0012	4·893	55·53	45·31
June . .	2·253	·4387	·3089	3·116	·0028	5·261	62·16	51·18
July . .	2·299	·3096	·2881	3·305	·0003	5·549	65·30	54·48
August . .	2·265	·3240	·2645	2·679	·0018	4·658	63·38	54·71
September .	2·007	·1686	·1217	1·521	·0018	2·931	57·61	52·22
October .	2·963	·9876	·9567	·825	·0378	1·554	49·26	45·75
November .	2·612	1·4314	1·6811	·426	·0654	·893	42·79	40·96
December .	2·199	1·6221	1·8324	·233	·1190	·670	37·75	35·93
Yearly average	25·456	10·8437	10·3425	18·137	·3589	33·850	49·50	43·87

difference between the rainfall and percolation being 11·3594 ins. In the year 1894 the rainfall was greater than in 1891, being 31·410 ins., and the percolation through the chalk gauge was considerably less, namely, 16·0093 ins., the difference between rainfall and percolation being 15·4007 ins. The reason for this increased loss is entirely due to the extra amount of grass which was grown; for in the year 1891 2·622 lbs. of grass were grown per superficial yard, whereas in 1894 3·258 lbs. of grass were grown from the same area. From experiments which were made by the author some years ago with reference to the amount of evaporation which took place from an area of Italian rye-grass, it was found that the evaporation associated with the growth of a given amount of grass was very considerable. For example, in the first year of growth, the plant irrigated every day between June 1870 and June 1871, evaporated a depth of 187·87 ins., and grew a crop of grass equal to a weight of 25·491 lbs. per super. yard, or it required 7·291 ins. in depth to produce 1 lb. of grass. In the same period of the following years, June 1871 to June 1872, the depth evaporated was 90·93 ins., and the weight of grass grown on a superficial yard 18·490 lbs., and it required 4·971 ins. in depth evaporated to produce 1 lb. of grass.

Sometimes very large rainfalls only produce very small percolation, as it will be observed that in September 1896 there were 7 inches of rain, but the amount which actually percolated in that month was only ·7403 in. In 1882 and in 1896 the rainfall was just over the average, but the percolation in those years was under the average. In the months of July, August, and September 1882 6·31 ins. of rain fell, but none of it passed through the percolating gauge; and so it will be observed that in many months together no percolation takes place, although there has been more or less rain.

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DISCUSSION.

Mr. W. MARRIOTT said that Dr. Mill had asked him to express his regret at his inability to be present at the meeting. Dr. Mill would have liked to take part in the discussion, for he had made a study of evaporation, and had taken a large number of observations from the evaporation tank which was first used at Strathfield Turgis, and afterwards removed by Mr. Symons to Camden Square. The subject of percolation was an interesting one, and there were several percolation gauges in use. Mr. Latham's observations were extremely valuable, not only for the length of time over which they extended, but also for the information they gave on a subject of which very little was known. Percolation gauges were used by Mr. Dickinson at Nash Mills until 1882, when apparently they were removed by Sir John Evans to Apsley Mills in 1883. Sir John Bennet Lawes and Sir Henry Gilbert had percolation gauges at Rothamsted, the results from which from 1870 to 1899 were brought before the Society in a paper by Dr. Scott in 1900. Mr. E. Mawley had two percolation gauges at Berkhamsted, one with grass, the other with bare soil. Mrs. Lyndon had also a percolation gauge at Grayshott on Hindhead. At Apsley Mills three gauges were carried on, one with chalk, one with sand, and the third with natural soil, that is, earth and grass. The average percolation for the twelve years 1884-1895 for chalk was 12·23 ins., for earth 13·07 ins., and for sand 16·71 ins. The average yearly rainfall for the same period was 26·20 ins. The percolation was greatest in the sand. At Rothamsted in ordinary soil the average percolation was 14·71 ins. Mr. Latham gave an average percolation by the chalk gauge of 10·84 ins. and 10·34 ins. by the gravel gauge, therefore his percolation was much less. Mr. Marriott also referred to the evaporation observations carried out by Dr. Mill at Camden Square, by Col. Knight at Harestock, by Major King at Isfield, by Mr. Haworth at Wakefield, and by Mr. Baxendell at Downholland, a few miles from Southport. He also exhibited lantern slides illustrating a comparison which he had made of the amounts of evaporation at Croydon, Camden Square, and Downholland. These showed that the records from Croydon and Camden Square agreed very closely between 1893 and 1906, but that previous to 1893 and also after 1906 the Croydon values were higher than those at Camden Square. These differences Mr. Marriott thought were due to the removal of the gauge at Croydon from one place to another, and tended to show that the results were not uniform throughout the series. At Downholland the curve followed pretty much the same course as that at Camden Square, but the evaporation was greater. This he believed was due to the larger amount of wind passing over the gauge, as it was placed in marshy land and had a very open exposure. He believed that the chief factors influencing evaporation were the dryness of the air, the temperature of the water, and the wind.

Mr. C. SALTER said that observations of evaporation from an exposed water surface had been carried on at Camden Square for a quarter of a century. During the last three years Dr. Mill had been experimenting with the object of ascertaining the relation of evaporation measurements to other meteorological elements. Curves had been drawn for the purpose of expressing this relation. In order to find the effect of wind on evaporation, a Robinson anemometer was set up with the cups 18 inches above the water. The results seemed to indicate that wind movement had but little effect upon the amount evaporated, the curves bearing no apparent relation, but a parallelism was shown between the curves of sunshine and maximum temperature, and those of evaporation during the summer months. The evaporation was more closely related to shade temperature in winter. It was remarkable that more meteorologists

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had not followed Mr. Latham's great lead in the matter of observations of evaporation and percolation, in view of the great practical bearing of this information upon questions of water-supply. What it was desirable to find out was what proportion of the rainfall was in nature actually lost by evaporation to the air, and what proportion absorbed by the soil to feed the streams and wells. The observations so far in some measure failed to indicate this. A percolation gauge in summer might sometimes dry up, but probably evaporation was always taking place from the soil because of the moisture drawn up from the almost inexhaustible supply below the ground. Evaporation measurements from a water surface, on the other hand, would probably give an unduly high value, because although evaporation could always take place from the ground, when the surface was parched the amount of water passing into the air could not be so great as from a free water surface. The true evaporation value must therefore lie somewhere between the results obtained by the actual measurements made in the evaporation tank and the results by difference from the percolation gauges. The tank, however, takes no account of the effect of vegetation in promoting evaporation, a subject which deserves a special investigation.

Mr. W. H. DINES said that, notwithstanding the excellent authority that had been given, he could not agree with the statement that wind was an unimportant factor. His father had made many observations on evaporation, and he recollected quite well that his opinion was that wind was important. Also it was a matter of common observation that the part of a garden or road that was wind-swept would soon dry, but that a sheltered part would remain damp. Neither did he think that the explanation of the discrepancy was far to seek. Firstly, there was most wind in winter when all the other factors were opposed to evaporation; secondly, in summer windy days were often damp and cloudy days, so that the existence of wind would in general go with a high relative humidity and a low temperature of the water, and these latter elements would mask the very favourable influence that wind had when the other conditions were also favourable. Probably it was the differences in the exposures of the evaporating tanks that produced the differences in the amounts recorded at various places.

Mr. J. E. CLARK said that the winds varied with the quantity of rain. A South-west wind was not only the strongest but the moistest. The fact that during the earlier part of the autumn the evaporation tanks were sheltered by trees, would make a very great difference, owing to the drying effect the wind had. He could speak from experience, as he resided on the very Riddlesdown whence the chalk percolator had come, where the north-east slope of the ground exposed it to the driest wind, and sheltered it from the others.

Mr. F. C. BAYARD inquired how Mr. Latham measured the evaporation while the gauge was frozen, and if these measurements were put down to the following month. Mr. Latham described his evaporator as being in the middle of a large tank, and he, Mr. Bayard, would like to know how the readings were taken of the evaporator. Of the two percolation gauges, apparently there was a greater percolation through the chalk than through the gravel; but he noticed that in different months the percolation was more through gravel than chalk. He did not know whether this was because the chalk was closer, and it took longer for the water to percolate through.

Dr. W. N. SHAW said that it would be desirable to have some more definite understanding on the merits of the term "evaporation." At present it might mean different things for different people, according to the conditions under which the water passed into the air. There must be some equation between the amount of water falling upon a percolation gauge and the amount disposed of in various ways. It was clear that what did not run away must be otherwise disposed of. Was the amount of evaporation that which must be added to the

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percolation in order to give the total rainfall? If so, what kind of surface, shallow water surface, deep water surface, soil, or vegetation, must there be in order that the two should make up the total rainfall? Thirty years ago he made a number of observations in order to compare different forms of evaporimeters, but comparison was impossible, because the conditions of evaporation were different in different instruments. The Society was indebted to Mr. Latham for an admirable paper on an interesting subject.

Mr. J. HOPKINSON said that Mr. Latham's experiments on percolation and evaporation were more complete than any which had hitherto been made, for they had not before had the weight of grass grown, nor the amount of condensation, the record of which he thought might have an important bearing on the study of dew-ponds. Comparisons with other experiments were valueless without the conditions under which they were carried out being stated. The percolation at Croydon was greater than had been recorded at Lea Bridge and Nash Mills, which he thought might be due to the soil not getting thoroughly consolidated owing to the frequent moving of the gauges. It was less than at Rothamsted, where the gauges were built round undisturbed soil, because there the surface of the soil was kept free from vegetation by being frequently hoed. Mr. Mawley had published the results of his earlier experiments on percolation at Berkhamsted,[1] but had since altered his two gauges, growing grass on one and not on the other, and he had been astonished to find how greatly vegetation reduces the amount of percolation. After the Nash Mills gauges were removed to a more exposed situation near Apsley Mills, the amount of percolation in relation to the rainfall had increased, but he had seen the two gauges there almost bare of grass in dry weather in the summer and autumn, while there was plenty of grass growing round them; doubtless because none of the rain which sank through the three feet of soil, then being collected, could get back again and rise to the surface to nourish the grass, and this might also be the case with the author's gauges. There could be no doubt of the drying effect of wind when the air was fairly dry, a strong wind often having more effect than a hot sun in drying a muddy road.

The PRESIDENT said that he wished to express to Mr. Latham their great obligation to him for collecting these results, putting them together, and discussing them. The subject was of increasing importance because of its influence on the water-supply of the country. He would like to ask Mr. Latham as to the diminution of evaporation from the gauges owing to their want of depth. Of the three gauges at Rothamsted at 20, 40, and 60 ins. deep, the results obtained at 20 and 60 inches were practically identical. At Rothamsted there was an increase in the amount of percolation since the gauges were started, and they had evidently got into a different condition from that of thirty years ago.[2] He would be glad to know whether Mr. Latham had noticed any progressive change in his gauges. He also inquired why the evaporation should not have been measured for the whole tank instead of in the smaller floating one.

Mr. B. LATHAM in reply said:—With reference to the remarks which have been made upon the paper, I do not consider it any detriment that the stations have been moved from time to time, during the 30 years in which the observations have been carried on, as it tends to equalise the effects, and shows the influence of elevation at the stations.

With regard to the form of evaporator which has been used, I consider this floating evaporator is infinitely superior to a tank of moderate size; first, on the ground that it is not liable to lose its shape and contents by frost, as the expansive force of frost on a tank is very considerable, and an ordinary square

[1] "The Percolation of Rain through comparatively Light and through comparatively Heavy Soil," *Trans. Herts. Nat. Hist. Soc.*, 1891, vol. vi. p. 175.

[2] See Dr. E. J. Russell in *Journal of Agricultural Science*, ii. 29.

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tank will very soon alter its capacity under the influence of severe frost, unless the ice is kept constantly broken. With the floating evaporator the ice forms inside the evaporator, and at the same time outside the evaporator, so that the frost within the evaporator is counteracted by the frost outside, and thus no change takes place in the form of the evaporator. Then again there is always the danger of losing water by means of animals and birds drinking from it. This is not the case with the floating evaporator, as every facility is given for birds to drink in the outer part of the tank, and consequently they leave the evaporator alone.

The mode of measurement of the evaporator is by means of a hooked gauge, with which it is measured with the greatest accuracy. With reference to what happens in time of frost, if it should happen, which it has done, that a frost occurs near the end of one month and the beginning of the next month, the evaporators are left alone until the ice has disappeared, and whatever has happened from the last measurement to the first measurement after the frost, is ascertained and divided out to each month in proportion to the number of days due to each month.

With the exposed evaporators in use, very great trouble is experienced in the winter-time, and they often burst, and we have to have relays of them in order to continue the observations during the winter; but, as a rule, this evaporator is taken into a cool house in time of frost, so as to get as much as possible out of its influence.

	Evaporation, Floating Evaporator at Croydon.	Horizontal movement of Air at Greenwich.
	Average for 10 years 1899-1908.	
	Ins.	Miles per hour.
January	·2885	14·68
February	·3140	14·07
March	·8025	13·73
April	1·6150	13·09
May	2·2220	11·17
June	2·8845	10·85
July	3·0848	9·66
August	2·5010	11·05
September	1·5300	9·87
October	·8515	10·86
November	·4460	11·59
December	·3040	12·70
Total	16·8430	...
Average	...	11·94
	Yearly Total.	Yearly Average.
1899	18·875	11·53
1900	16·160	12·17
1901	16·685	11·52
1902	14·935	11·37
1903	16·020	13·32
1904	15·435	11·39
1905	15·385	12·31
1906	15·950	12·49
1907	20·110	11·80
1908	18·875	11·52
Average	16·843	11·94

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With reference to the question of wind there are, no doubt, certain times when wind does have some effect upon evaporation, but the influences are not so considerable as many persons imagine. At the author's stations there were no convenient places for recording the velocity of the wind, and therefore he has always taken the Greenwich record as being sufficiently near for the purpose of ascertaining the relative influence of wind; and he has had got out for the last ten years a table which shows on the average the amount of evaporation which has taken place each month, the horizontal movement of the air at Greenwich in miles per hour each month, and the yearly average. From the Table it will be seen that the greatest amount of evaporation took place in 1907, equal to 20·110 ins., while the average velocity of the wind in that year was but 11·8 miles per hour, or under the average.

It will be noted that we have the least wind on the average when we have the greatest evaporation, but this does not show that wind has no effect upon evaporation, but that the temperature has a considerably greater effect, and that when the dew-point is taken into consideration in connection with evaporation it should be borne in mind that the tensional difference is often influenced by the effect of wind, and therefore it is a measure of the influence of wind upon evaporation.

With reference to the quantity of water evaporated from the ground, there is no doubt, that owing to the temperature of underground water, which in winter has a much higher temperature than surface water, and that at other periods of the year the temperature of the underground water is greater than the temperature at some distance below the surface of the ground, considerable quantities of water are brought up from the subsoil water by evaporation, and often condensed near the surface where the ground is of a cooler temperature, as the temperature of the ground varies at different depths at every period of the year. It has been ascertained beyond doubt, by the gaugings of chalk streams in the neighbourhood, that the actual flow of water off the ground bears a somewhat less proportion to the rainfall than is indicated by the percolation gauges.

The Recording of Rainfall.

Dr. H. R. Mill, in a lecture on "The Measurement of Rainfall," which he delivered before the Association of Water Engineers, made some remarks about the recording of rain. He said, "So far as I am concerned the recording of rain is of greater importance than the measurement, because good measurements may be spoilt by bad records. I am happy to say that most of the thousands of rainfall records I receive are nearly perfect as regards neatness and legibility. The points of perfection are, first, that the amount of rain is put down beside the proper date. That is one of the most serious difficulties. People measure the rainfall, or ought to measure it, at 9 o'clock in the morning, and they are apt to put it down for the morning on which it was measured. You will see that only a small portion of the rain on an average can have fallen that morning; most of it is for the day before. The rule is to put it down to the day before the one on which the reading is taken, and as most people conform to this rule the cases in which it is neglected can usually be detected; but if not detected a wet day may disturb the relative fall of two months or even of two years. Another thing is the redundancy of figures. Some people put '0·00' on days when no rain fell, and so fill up the sheet unnecessarily. An extra cipher is not only of no use; it may be mistaken for a 6, and I have had cases of ·06, ·60, or even ·66 being copied from the '0·00' of a careless scribe. A dot or short stroke is the best way of indicating

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a rainless day. The second thing is that the reading should always be given to two places of decimals; the third place is unnecessary, because the instrument is not accurate enough to show 1000ths of an inch with certainty. Some conscientious observers write the word 'nil' when there is no rain, and this makes it troublesome to add up the column.

"The great secret in recording is to make such records as will give the smallest number of opportunities for mistakes; but mistakes, such as every one makes occasionally, will occur, though this is a point I have found most difficult to bring to the minds of foremen in charge of works; nothing will ever induce some men of that class to acknowledge that a mistake has been made, because he knows that no one is absolutely perfect. It does not make an error any better to stick to it, though this is often done. On one occasion in the lifetime of the late Queen Mr. Symons convicted an observer of having made a mistake. The observer acknowledged it; but he would not allow it to be rectified because the figures had been submitted to Her Majesty!

"Some records show quite plainly that the observer has not been conscientious in visiting the rain-gauge daily. A record which shows 50 or 100 fewer days with rain than other records in the neighbourhood is simply not true as regards rain days; and we know it perfectly well when we see it, but it may be correct as regards total quantity. There are a great many other mistakes which we can detect, and experience makes some of these very easy to find, but sometimes difficult cases arise. I have found on more than one occasion when a record is kept by an illiterate man we are able to make a good account of it, knowing the pitfalls to avoid; but we have sometimes had great difficulty in dealing with very neat copies of similar records made by a clerk ignorant of the errors and inconsistencies likely to occur.

"It is most important to have a full daily record when errors have to be looked for; but it is a convenience to have this supplemented by a summary giving the monthly totals and the fall of the wettest day in each month, because that forms an independent check on the total of daily readings. Supposing an observer gets 1½ inches of rain, he measures it in a ½-inch glass, and perhaps forgets whether he has filled and emptied the glass three times or four, or two, and so may make a mistake of a ½ inch or more. This can usually be detected by comparing several neighbouring returns. In order to reduce the risk of this very common error I have endeavoured to persuade manufacturers to graduate the bottles placed inside the rain-gauge as well as the glass, so that one can read off the bottle the number of ½ inches, and then measure exactly to 100ths of an inch by the glass. Generally speaking, rainfall observers are conscientious and accurate, the careless or dishonest observer is the exception; and so when there is a sufficient number of observers in a small area any serious mistake made by one in his records will be out of harmony with those surrounding. When we get (say) a very low rainfall reported from a point surrounded by higher values, we can be pretty sure that there is something wrong. Every month I prepare a map of the rainfall of the British Isles from about 1000 returns, and the mere placing of the figures on the map subjects them to considerable tests, and frequently enables us to detect cases of error."

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THE METEOROLOGICAL CONDITIONS IN THE PHILIPPINE ISLANDS, 1908.

By Rev. JOSÉ ALGUÉ, S.J., Hon.Mem.R.Met.Soc.
Director, Philippine Weather Bureau, Manila Observatory.

[Read April 21, 1909.]

The general impression left by the year which closed on December 31, 1908, was that it was one of extraordinary meteorological conditions and events. Extraordinary have been the floods, and extremely severe and frequent the cyclonic storms that have passed over or exerted their influence on the Archipelago. The island of Luzon has been the one that suffered most from inundation and cyclone, yet, with the exception of Mindanao, Bohol, and adjacent islets, there has been no island that has not been visited more or less severely by heavy winds and cyclonic rains, and experienced the consequent floods and devastations.

These cyclonic tempests and inundations suppose an alteration in nearly all the meteorological elements. For this reason, it will not prove uninteresting to study briefly the amount of change experienced in different localities of the Archipelago, in order to obtain some idea of the characteristics peculiar to this year in a meteorological sense. We will fix our attention in a special manner on Manila, where these elements have been observed more closely, and because the capital was located almost in the centre of the zone comprising Luzon and the northern Visayas, zones most severely visited, our observations will indicate better and more universally these characteristics.

We will consider principally the alterations in the atmospheric pressure and precipitation, since these elements are more nearly related to storms and floods. The other elements, although very important for a study of the climate, we will take into account only in so far as they help us to understand the meteorological physiognomy, if I may be allowed such an expression, of the year 1908.

January.—The atmospheric pressure was somewhat greater than the normal throughout the Archipelago. In Manila the monthly mean showed a difference of + 0·94 mm. [+ ·037 in.] from the normal mean for January—the average for the past twenty-four years, which is given as 761·16 mm. [29·967 ins.]. In general, the normal was exceeded in the whole Archipelago, and the month was free from atmospheric depressions. The other elements did not show any great differences from the preceding year.

February.—Although the Archipelago was not affected by any important depressions, nevertheless the atmospheric pressure was everywhere lower than the normal of this month, and in Manila the mean for the month was less by 1·59 mm. [·063 in.] from that of 761·39 mm. [29·977 ins.], the normal for February. As an effect of the low atmospheric pressure the stations of Luzon reported a larger amount of rainfall than the average; while in the Visayas, in spite of the contrary effects of the North-east monsoon, the precipitation was a little less than in February of other years. The temperature showed no very great

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change from preceding years, but was a little lower in Manila and some other points.

March and April.—The mean pressure for March was a little below the normal, owing to the influence exerted by two depressions, one in Luzon and the other in the southern islands. This slight difference was general throughout the Archipelago. Likewise in all the districts the precipitation was rather heavier than in the preceding year, and even than the normal. The elements in Manila were more normal during the month of April, and in spite of the fact that in nearly all parts of the Archipelago the atmospheric pressure was less than the average, still everywhere temperatures a little higher than the means were registered. The rainfall was very unequally distributed, for, while in Manila, Corregidor, and Batangas not one drop of rain fell during the entire month, in other islands and in other parts of Luzon the precipitation exceeded the normal.

May.—The first three weeks of this month were nearly normal; nevertheless, on account of the widespread influence of a cyclonic centre in the China Sea during the last days of the month, the weather in the Archipelago, and especially in the island of Luzon, was extraordinary and exceptional, so that the mean atmospheric pressure of the month throughout the islands was less than the normal pressure. The quantity of rainfall was greater than the average, particularly in the north-west of Luzon and along the western coasts of this island, with the result that the precipitation of this month in Manila exceeded the normal by 366 mm. [14·41 ins.] and was the greatest quantity recorded for this city in the month of May since the foundation of the Observatory in 1865.

This typhoon was formed in the China Sea near parallel 15° and meridian 113° east of Greenwich, and remained almost stationary from the 23rd to the 26th. It passed the meridian 115° to the west of Cape Bolinao, moving almost north-east-by-east, and threatening to cross the north-western extremity of Luzon. On the 28th the vortex came nearest to Cape Bojeador, and made a slight inclination to the east after having crossed the 120th meridian, and subsequently passed over the Babuyan Islands and the Balintang Channel. The winds were of hurricane force in Vigan from early in the morning till mid-day of the 28th, and in Laoag from 8 a.m. to 2 p.m. of the same day; so that there was considerable damage done by the winds and rains to buildings and crops in the northern part of Ilocos Sur and throughout the province of Ilocos Norte. The floods of the Abra, Casilian, and Bagbab rivers in the provinces of Ilocos helped the destruction of the crops. The rainfall records of this typhoon on the western coasts of Luzon were: Laoag, 255 mm. [10·03 ins.]; Vigan, 262 mm. [10·32 ins.]; Candon, 203 mm. [7·99 ins.]; San Fernando (Union), 57 mm. [2·24 ins.]; Bolinao, 176 mm. [6·93 ins.]; Dagupan, 108 mm. [4·25 ins.]; Olongapo, 207 mm. [8·15 ins.]; Manila, 134 mm. [5·28 ins.].

June and July.—After such extraordinary weather at the end of May, the following two months slipped by almost without any noteworthy disturbance, with the effect that the atmospheric pressure was somewhat higher than the normal of June and July, and the precipitation much less than that of other years. There were no areas of low pressure during June other than that on the 19th in the China Sea, and another to the

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east of southern Luzon, both of which were of little importance. In July the typhoon which proved so disastrous for Hong-Kong exerted some influence on northern Luzon while it was crossing the Balintang Channel on the 26th of the month.

August.—The month opened with very complicated weather, owing to the simultaneous existence of various depressions, which, though not of great importance if we regard the force of the wind only, nevertheless were accompanied by extremely heavy rains, especially in Luzon, causing floods in the central and northern provinces, chiefly in Pampanga and Bulacan, where the crops suffered immensely. In Manila, for the first ten days only, the rainfall recorded was 432 mm. [17·01 ins.], a quantity greater than the average for the whole month. On the 16th a cyclone appeared in the Pacific to the east of Formosa, and a depression in the north-eastern section of the China Sea; but neither affected Luzon to any marked degree. Another cyclone, of little importance for the Archipelago, recurved in the Pacific to the east of Luzon from the 19th to the 21st, and then increasing in intensity, moved away from the island. The effect of all these depressions was a heavy precipitation in Luzon during the first part of the month, followed by large floods in the central and northern provinces of this island.

September.—The first two decades of the month were free from any important atmospheric agitation, and, for this reason, in Manila, and at many other stations, from the 1st to the 20th the mean atmospheric pressure exceeded the normal. On the other hand, in the last decade the mean pressure was much lower in nearly every part of the Archipelago. One of the most terrible typhoons that have affected the Archipelago of late years crossed the Visayas on the 23rd, completely upsetting atmospheric conditions for some days. This typhoon is comparable in intensity with that of Samar and Leyte of October 12, 1897, and also with the Cantabrian cyclone of September 25, 1905.

Throughout the whole extension of its path (see Fig. 1), there were winds of hurricane force covering a zone more than 30 miles wide on both sides of the vortex. From this may be imagined the destruction wrought on land and sea when the typhoon crossed Samar and passed close to Masbate, Romblon, Tablas, and Mindoro. The barometric minimum of Borongan is one of the lowest that have been recorded for many years. The belt of rainfall was 300 miles wide along the path, and, as generally happens, the maximum intensity was observed in the vicinity of the vortex. In Calbayog the amount of rainfall from the 20th to the 25th was 318 mm. [12·52 ins.]; in Gubat, 118 mm. [4·65 ins.]; in Masbate, 127 mm. [5·00 ins.]; in Atimonan, 250 mm. [9·85 ins.]; in Tarlac and Echague, in the interior of Luzon, 159 mm. [6·26 ins.] and 106 mm. [4·18 ins.] respectively. In the northern part of Luzon the precipitation was much lighter, as in Tuguegarao only 55 mm. [2·17 ins.] were registered for the same period.

October.—This and the following month were remarkable for the severity and frequency of cyclonic storms. Three typical typhoons crossed Luzon from the 3rd to the 13th, causing great loss of life and property by the violence of the wind and the magnitude of the floods. The paths of these cyclones are given in Fig. 1. In the first of these cyclones there was a zone, 30 miles wide in and near the vortex, in

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which the winds were extremely violent. In the second, the winds, though of hurricane force, did not cover such an extensive area as in the former cyclone; but this typhoon was remarkable for the quantity of rainfall from Manila even to the northern extremity of Luzon. The third was the severest both in the force of the winds, which covered a remarkable area, and also in the torrential rains. These rains, together with those of the second cyclone of this month, were the cause of inundations that have seldom occurred before, especially in the River Agno, which destroyed several kilometres of the track of the Manila and Dagupan Railway; in the Bued, which swept the plain of Pozorrubio, and caused serious damage to the Benguet road; in the Cagayan and its branches, spreading death and desolation through the whole valley,

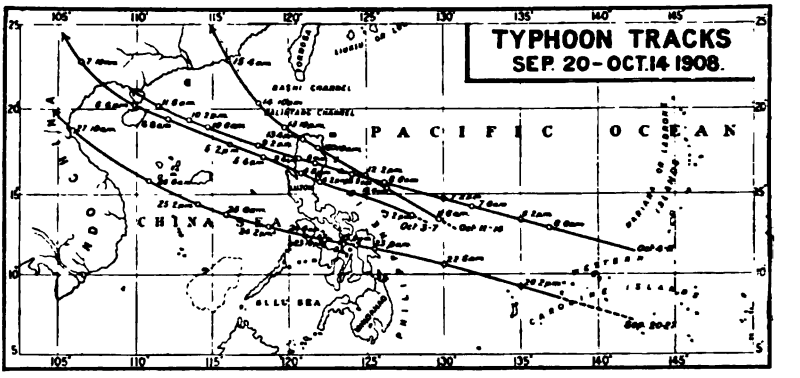


FIG. 1.

especially from Lalo to the sea. The floods in the other provinces to the north of Manila were no less terrible, as was also that of La Laguna in the slopes of Maquiling and San Cristobal.

The rainfall from October 1 to 15 was:—Tuguegarao 399 mm. [15·71 ins.]; Baguio 1283 mm. [50·51 ins.] (459 mm. [18·07 ins.] on the 13th and 14th); Tarlac 245 mm. [9·65 ins.].

November.—Rev. José Coronas, Assistant Director, the forecaster in charge of the department of meteorology, made the following brief *résumé* for the public of the meteorological conditions during this month, to which has been added only the records of rainfall during the two more important cyclones of the month. The track of the cyclone which affected the island of Luzon on the 20th is given in Fig. 2.

We wish to call attention to the abundant rains over the greater part of the Archipelago during the latter half of the month. The total rainfall in Manila for the month was 218·5 mm. [8·60 ins.], which is 174·4 mm. [6·86 ins.] above the total for November 1907, and 86·9 mm. [3·42 ins.] above the normal for the month; but when we receive the observations from the provinces the difference will be found to be much more extraordinary in the stations of the Visayas and the south-east of Luzon.

Likewise we deem worthy of mention the tracks of the typhoons or depressions which have visited the islands from the 13th to the 21st. One de-

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pression formed in the Jolo [Sulu] Sea and moved north-east and east-north-east until it appeared near the Catanduanes Island, where it remained stationary for one or two days, and then turned west or west-south-west towards the China Sea. This extraordinary movement is almost unknown in our latitudes, but it is what actually occurred in the depression of the 13th to 17th.

No less strange was the case of the typhoon of the 20th, which on that day crossed the island of Luzon, somewhat far to the north of Manila, that is to say, between the parallels 16° and 17° north. It is not surprising then that, after a path so extraordinary for this season of the year, it recurved in the China Sea,

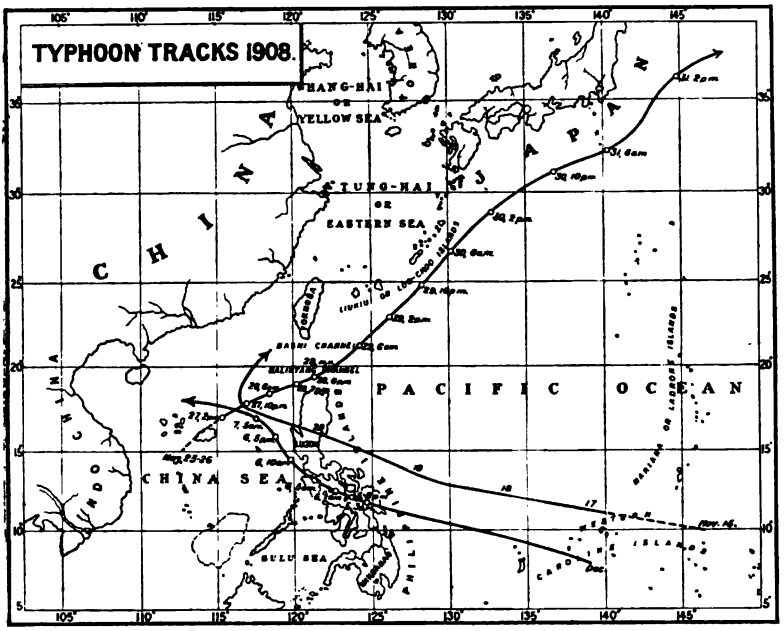


FIG. 2.

and finally filled up and disappeared west of the Balintang Channel. This typhoon crossed the centre of the island of Luzon on the 20th; but the Observatory sent the first warning of its existence to Indo-China, China, Formosa, and Japan, at 5 p.m. on the 15th, when the centre of the disturbance was located to the south-south-east of the island of Guam. From that day the course of the typhoon was followed daily until its filling up in the China Sea was announced by telegram to Hong-Kong at 5 p.m. on the 22nd, seven days after its appearance to the south-south-east of the Ladrone Islands.

Rainfall from November 10 to 30:—Borongan 158 mm. [6·22 ins.]; Gubat 264 mm. [10·39 ins.]; Atimonan 894 mm. [35·20 ins.]; Masbate 298 mm. [11·73 ins.].

The mean atmospheric pressure was lower than the normal at almost all the stations in the Archipelago. In Manila the difference was −1·11 mm. [−·04 in.].

December.—During the first days of this month the weather was

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extraordinary, owing to a cyclone that crossed the Visayas, and disturbed, to a remarkable degree, atmospheric conditions in this region, in the inter-island seas, and the southern part of Luzon. As a result, in Manila the pressure during the first decade of the month was less by 3 mm. [·12 in.] than the normal for December. Likewise, in the southern part of Luzon and in the Visayas it was lower than the average. In Borongan the barometric minimum, 719 mm. [28·308 ins.], was registered on the 5th, the lowest reading for December since pressures were first recorded in the Archipelago. The amount of rainfall in the neighbourhood of the vortex was remarkable, as, for instance, the records show for Borongan, from the 2nd to the 7th, 211 mm. [8·30 ins.], for Calbayog and Gubat 131 mm. [5·15 ins.] and 175 mm. [6·89 ins.] respectively, for Calapan (Mindoro) 322 mm. [12·68 ins.], during the same period, while in Manila during the first decade alone the precipitation was as heavy as the normal for the whole month. See track in Fig. 2.

Conclusion.—What has been said above will be quite sufficient to indicate that 1908 was an extraordinary year, and this is conclusively shown by comparing the greatest cyclonic storms that have affected these islands since 1880—a space of twenty-nine years. In the following table only those storms in which the barometric minimum has fallen below 741 mm. [29·174 ins.] at some point of the Archipelago are taken into account, because these are destructive typhoons almost without exception, or, at least, indicate that the vortex has passed over some island or very near to it. It is well known that these barometric minima do not always correspond to the pressure in the vortex, but they always show the lowest readings at points not far distant from it. We distinguish three degrees of intensity in destructive cyclones. The number 1 indicates regular intensity, 2 remarkable intensity, and 3 extraordinary intensity.

From this table we can deduce consequences of the highest importance:—

1. Of these twenty-seven destructive cyclones in the Philippines during the last twenty-nine years, only fourteen have been classified as typhoons of extraordinary intensity, and of these fourteen, five correspond to the year 1908.

2. Of these twenty-seven only three recorded barometric minima lower than 700 mm. [27·560 ins.], namely, those of October 1897, September 1905, and September 1908. It should be remarked here that these three terrible cyclones crossed the Visayan Islands, entering by Samar, that is, between parallels 11° and 13° N.

3. Only sixteen of the cyclones included in the table recorded minima less than 730 mm. [28·741 ins.], and of these sixteen, six took place in the year 1908.

4. The really destructive cyclones, and those which have attained a sinister fame among us, as those of October 1882 in Manila, of November 1890 in Albay, of October 1893 in Tuguegarao, of July 1895 in Aparri, of October 1897 in Samar and Leyte, of 1903 in Tuguegarao, and the Cantabrian cyclone of September 1905, are rare indeed, so that this year is remarkable in that there occurred three typhoons of this type, namely, those of September 23, October 13, and December 5.

5. It seems that the part of the Archipelago that is visited the most frequently by these extraordinary typhoons is the northern part of Luzon

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from the parallel 15° 30′ to the Batanes Islands and from parallel 11° to 14° N.

DESTRUCTIVE CYCLONES. Minimum 741 mm. [29·174 ins.] or less.

Cyclone Number.	Station.	Date.	Barometric minimum.		Intensity.
			mm.	ins.	
1	Manila	Oct. 20, 1882	727·75	28·652	3
2	Manila	Nov. 5, 1882	735·79	28·969	2
3	Aparri	Sept. 26, 1888	727·42	28·639	1
4	Albay	Nov. 15, 1891	727·80	28·654	3
5	Albay	May 14, 1893	737·00	29·016	2
6	Tuguegarao	Sept. 30, 1893	710·45	27·971	3
7	San Isidro	Sept. 17, 1894	736·80	29·008	1
8	Aparri	Nov. 16, 1894	730·26	28·751	2
9	Aparri	Nov. 2, 1895	740·79	29·166	1
10	Aparri	July 27, 1896	716·30	28·201	3
11	Aparri	Oct. 19, 1896	740·00	29·134	2
12	Tanawan (Leyte)	Oct. 12, 1897	693·98	27·322	3
13	Capiz	June 3, 1903	740·80	29·166	2
14	Aparri	Oct. 20, 1903	735·35	28·951	2
15	Tuguegarao	Oct. 25, 1903	720·45	28·365	3
16	Baler	April 29, 1905	738·00	29·056	2
17	Santo Domingo (Batanes)	July 1, 1905	713·15	28·077	3
18	SS. *Pathfinder*, Lat. N. 12° 10′ 35″, Long. E. 125° 31′	Sept. 25, 1905	690·12	27·171	3
19	Aparri	Sept. 19, 1906	735·90	28·973	2
20	Baler	Sept. 27, 1906	707·90	27·871	3
21	SS. *Liscum*, Santa Rita (Samar)	Jan. 10, 1907	735·70	28·965	1
22	Aparri	May 28, 1908	738·70	29·083	2
22	Bark *Kohala* (off W. coast Luzon)	May 27, 1908	722·11	28·430	3
23	Borongan	Sept. 23, 1908	698·00	27·481	3
24	Baler	Oct. 4, 1908	715·00	28·150	3
25	Echague	Oct. 8, 1908	721·00	28·386	2
26	Tuguegarao	Oct. 13, 1908	711·00	27·993	3
27	Borongan	Dec. 5, 1908	719·00	28·308	3

DISCUSSION.

Colonel H. E. RAWSON called attention to the author's work entitled *Baginos ó Ciclones Filipinos*, which was published in 1897. A summary of a lecture by Dr. Bergholz, delivered to the German Association in Munich in 1899, dealing with this excellent report of the places of origin, paths, and zones of the hurricanes of the Far East, appears in this Society's *Quarterly Journal* for April 1900, vol. 26, p. 165. It has been translated from the German account, and as Señor Algué's work is in Spanish, the original has suffered considerably in translation. The paper is a very valuable one, and the credit of it should be given to Señor Algué, and not to Dr. Bergholz, whose lecture was largely a translation of the former's book. Owing to the longitudes being reckoned from San Fernando in the original, Dr. Bergholz converted them into meridians east of Greenwich, but in doing so some clerical errors in this and other matters have occurred. Colonel Rawson supplies the following corrigenda which require to be made:—p. 166, line 29, 129° E. instead of 149° E.; p. 166, line 4 from bottom, 124° E. instead of 130° E. The word "vertex" appears on p. 127 instead of "vortex"; where "north-west by north" occurs, it should be "west-north-west." In all cases in which conclusions are given they should be credited to Señor Algué and not to the lecturer.

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The present paper should be read in connection with the above. It confirms the important view which was advanced in 1897, that there is an intimate connection between the place of origin of typhoons, the sun's declination, and the position of the high-pressure systems in the vicinity. Señor Algué divided the year into three groups of months, the first including December to March, the second the months of April, May, October, and November, and the third June to September. He found that in the first group the greatest number of hurricanes arises in lower latitudes than 10° N., but at the beginning of December and the end of March the place of origin extends itself a little farther north, so that in the second group the place of formation lies between 6° N. and 17° N., and in the third between 8° N. and 20° N. The tracks of the hurricanes were discovered to vary with the positions of the two neighbouring high-pressure systems, the Siberian and North Pacific anticyclones, and to have a seasonal migration with them and with the two low-pressure systems in Hindustan and the Behring Sea. On November 20, 1908, we see that a typhoon took an extraordinary track for the season of the year, and passed well north of Manila. The "crossing line" of typhoons north and south of the Manila observatory, from 1879 to 1896, was found to occur in November, and no typhoon ever passed north of it from December to March in those years. Señor Algué attributed this to the rise of barometric pressure over the high-pressure district in Asia, which "pushed" the hurricanes into lower latitudes. We may therefore infer that the extraordinary floods and extremely severe and frequent cyclonic storms in 1908 may be partially attributed to the Siberian system being in an abnormal position. All the facts point to its being more northerly than usual. When we remember that the regions to the east of Central America and of South Africa resemble the Philippine Archipelago off the coast of China, in being sown with islands and being subject to a sub-tropical climate, we cannot help recognising the important part which the neighbouring anticyclonic systems play both in warding off and in governing the typhoons which probably originate from the prevailing contrasts of temperature. Colonel Rawson welcomed the paper as a valuable contribution to our knowledge of an interesting hurricane-area.

Commander W. F. CABORNE remarked that this paper was one of considerable interest, particularly to seamen frequenting Far Eastern waters, and that the best thanks of the Society were due to its author. The exceptional character of the weather in the year 1908 in the Philippines and their neighbourhood was fully demonstrated by the fact that, while fourteen typhoons of extraordinary intensity took place in the years 1880 to 1908, only nine of them occurred prior to the latter year. However, an idea of the generally stormy nature of the region could be formed from the fact that, according to the *China Sea Directory*, which had derived some of its information from *The Cyclones of the Far East*, by Father Algué, the typhoons which appeared in the Philippine Archipelago, either crossing it or passing through it for a greater or less distance, were 468 in number between the years 1880 and 1901 inclusive, giving an average of 21·27 per annum. Those who had never witnessed a destructive hurricane of the strength of a first-class typhoon or cyclone, would have some difficulty in realising the violence of the wind upon those occasions, and his (Commander Caborne's) experience in that direction had been confined to the great cyclone in the Bay of Bengal in October 1867, when the frigate-built East Indiaman *Blenheim*, in which he was then serving as a midshipman, after passing through the calm centre of the storm, was thrown on her beam-ends (no sail at the time being set), totally dismasted, and nearly lost.

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PROCEEDINGS AT THE MEETINGS OF THE SOCIETY

March 17, 1909.

Ordinary Meeting.

HENRY MELLISH, Esq., F.R.G.S., President, in the Chair.

WILLIAM HARVEY BROWN, Standard Buildings, Leeds;
Col. CHARLES ROSDEW BURN, Fyvie Castle, Aberdeenshire;
J. EDWARD BURNETT, 53 Percy Park, Tynemouth;
Capt. STEPHEN ALONZO PIDGEON, 87 Leadenhall Street, E.C.;
Capt. MONTAGU SYDNEY HERBERT SMITH, Highfield, Southampton;
EDWARD KEMP TOOGOOD, F.L.S., Southampton;
Capt. THEOPHILUS TROTTER, Western College, Plymouth;
ROBERT HEYWOOD WILSHAW, M.B., D.Ph., Town Hall, Worthing; and
HARRY EDWIN WOOD, The Observatory, Johannesburg, Transvaal,
were balloted for and elected Fellows of the Society.

Prof. CLEVELAND ABBE, F.R.A.S., Weather Bureau, Washington, U.S.A.;
JOHN RICHARD SUTTON, M.A., D.Sc., Kimberley, Cape Colony; and
LÉON TEISSERENC DE BORT, 33 Rue Dumont d'Urville, Paris,
were balloted for and elected Honorary Members of the Society.

The PRESIDENT said that he had the pleasure of introducing to them the Lecturer for that evening, Dr. Vaughan Cornish. Dr. Cornish was an authority on the subject of his lecture, and had travelled a great deal with the object of observing the formation of these waves. Some of them might have seen specimens of Dr. Cornish's work at the Franco-British Exhibition, and they were looking forward to seeing more of it that evening.

Dr. VAUGHAN CORNISH, F.R.G.S., then delivered a Lecture on "WIND-WAVES IN WATER, SAND, SNOW, AND CLOUD" (p. 149).

The PRESIDENT said they were much indebted to Dr. Cornish for his Lecture. All present would have now a much clearer opinion of wind-waves. It was a puzzling subject to most people, and they had had a great deal of information given them that evening. The photographs had been extremely successful in depicting the phenomena to them. He wished to tender their very best thanks to Dr. Cornish for his Lecture.

April 21, 1909.

Ordinary Meeting.

HENRY MELLISH, Esq., F.R.G.S., President, in the Chair.

Prof. HOWARD TURNER BARNES, D.Sc., M'Gill University, Montreal;
WILLIAM RICHARDS BLAIR, Ph.D., Mount Weather, Virginia, U.S.A.;
Prof. JAMES EDWARD CHURCH, Ph.D., University, Nevada, U.S.A.;
HENRY BLANCHARD HERSEY, Weather Bureau, Milwaukee, U.S.A.;
Capt. JOSEPH EDMUND LEACH, 103 Calabria Road, Highbury;
ERIC REXFORD MILLER, Weather Bureau, Madison, Wisconsin, U.S.A.;
ERNEST CLAUDE SHANKLAND, Morshed Mansions, W.; and
Capt. THOMAS JASPER UREN, Royal Albert Docks, E.,
were balloted for and elected Fellows of the Society.

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The PRESIDENT said that before proceeding to the reading of the papers, he wished to refer to a loss which the Society had sustained in the death of Captain Henry Toynbee. Captain Toynbee was at one time Superintendent of the Marine Department of the Meteorological Office, and had also served for some time on the Council of the Society. In point of years he was one of the oldest Fellows, being over 90 years of age, and he had been a member of the Society for 30 years.

The PRESIDENT than referred to the recent Expedition to the South Pole undertaken by Lieut. Shackleton, and said that they would look forward to hearing more details of the meteorological results. Meteorological data were steadily accumulating about that region. Several sets of observations had been published last year, and he hoped that with the fresh results now obtained, some Fellow of the Society would collect them and give the Society a first-rate discussion.

The following communications were read :—

1. "PERCOLATION, EVAPORATION, AND CONDENSATION." By BALDWIN LATHAM, M.Inst.C.E. (p. 189).

2. "THE METEOROLOGICAL CONDITIONS IN THE PHILIPPINE ISLANDS, 1908." By Rev. JOSÉ ALGUÉ, S.J., Hon.Mem.R.Met.Soc. (p. 213).

CORRESPONDENCE AND NOTES.

Mr. Shackleton's Antarctic Expedition.

We have much pleasure in announcing that at an early Meeting of the Royal Meteorological Society next session Lieut. J. B. Adams, who had charge of the meteorological observations, will give an account of the meteorological work of the Expedition. Mr. E. H. Shackleton and other members of the Expedition will also attend the Meeting.

Agricultural Education and Meteorology.

For some years past the Journal and Education Committee of the Royal Agricultural Society of England have organised an Agricultural Education Exhibition in connection with their Annual Show. This Exhibition has grown considerably, and that held in connection with the recent Show at Gloucester, June 22-26, was the largest of the series. It is pleasing to note that the subject of Meteorology is now beginning to be recognised by Educational Authorities. There were several specimens of meteorological work in the County Councils exhibit from the Elementary Schools in Gloucestershire, Herefordshire, Oxfordshire, Somerset and Wilts, including specimens of home-made instruments, which, although of a type hardly to be recommended, showed great ingenuity on the part of the teachers and scholars. Some of the children's notebooks, with remarks on their own observations of the weather, were very well kept,—in fact, some official observers might with advantage follow the example set by these records.

The Wye Agricultural College, Kent, showed photographs illustrating the methods adopted for the protection of fruit trees from frost.

The Harper-Adams Agricultural College, Newport, Salop, showed, by means of 36 bottles containing coloured substances, the results of an interesting experiment giving the rainfall and the amount of Nitrogen as Ammonia and Nitrates brought down by the rain over $\frac{1}{8}$th of an acre during each month of 1908.

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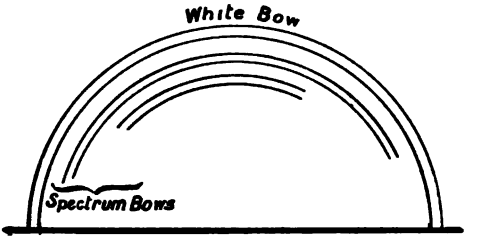
1908.	Rainfall by 5-in. gauge.	Nitrate of Soda.	Sulphate of Ammonia.
	in.	oz.	oz.
January	1·11	0·5	1·5
February	1·26	0·3	0·7
March	2·59	0·95	2·25
April	2·12	1·0	2·75
May	2·21	0·6	1·25
June	2·32	1·5	2·60
July	3·16	0·9	2·75
August	2·70	0·6	1·60
September	2·09	1·4	3·60
October	1·57	0·75	1·80
November	1·68	0·42	1·20
December	2·03	0·85	2·25

The Royal Meteorological Society organised a fully representative Exhibit, as well as a Climatological Station in the grounds. This Exhibit included diagrams, giving a great deal of useful information in a popular form, a varied collection of photographs of meteorological phenomena, and various patterns of meteorological instruments. Two self-recording rain-gauges, viz. : Messrs. C. F. Casella and Co.'s new Self-Recording Rain-Gauge, tipping-bucket pattern, recording down to ·005 of an inch, and Messrs. Negretti and Zambra's new Self-Recording Rain-Gauge, the "Hyetograph," were shown in public for the first time. Mr. W. Marriott gave a Demonstration each day on the "Method of taking Weather Observations." These Demonstrations, which included the ascent of ballons-sondes with meteorograph [1] or pilot balloons for ascertaining the drift of the upper currents of the atmosphere, were attended by large and interested audiences.

On Friday, June 25, a Conference of Teachers in Elementary Schools was held in the Members' tent, when Prof. Ainsworth Davis, Principal of the Royal Agricultural College, Cirencester, gave an Address on Nature Study, and Mr. W. Marriott spoke on the desirability of observations on the weather being taken up in Elementary Schools.

A Remarkable Rainbow.

During a sharp storm of rain and hail on Sunday, March 7, at 3.55 P.M., a remarkable rainbow was seen here. When first observed only an outer bow was visible, in colour white, standing out with marked distinctness against blue-black cumulo-nimbus cloud, the sun at the time being immersed in cirro-stratus.



On the cirro-stratus becoming less dense at 4 P.M., two incomplete inner bows were noticed showing the usual spectrum colours, the smaller of the two being both brighter and broader. The inner bows disappeared at 4.6 P.M. on the cessation of the rain. The white bow remained visible to 4.12 P.M., and before finally disappearing had a faint yellowish tinge. Cirro-stratus was seen above

[1] The balloon sent up on June 23 reached a height of nearly 12 miles, and fell near Marlborough in Wiltshire.

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the cumulo-nimbus. The illustration shows the formation of the bow at 4 P.M. —SPENCER C. RUSSELL, Epsom, Surrey.

Upsala Meteorological Observatory.

Professor Filip Åkerblom has from May 1, 1909, been definitely appointed Director of the Meteorological Observatory of the University of Upsala, Sweden, in succession to Dr. H. H. Hildebrandsson, resigned.

International Commission of Scientific Aeronautics.

The sixth Meeting of the International Commission of Scientific Aeronautics was held at the new Oceanographical Museum, Monaco, on April 1-6, 1909. Fourteen countries were represented at the meeting, and amongst those present were, Prof. Hergesell, the President, Profs. Assmann and Berson, Germany; M. Teisserenc de Bort, France; Prof. H. Hildebrandsson, Sweden; Prof. A. L. Rotch, United States; Col. Vives y Viches, Spain; General Rykatcheff, Russia; Prof. Palazzo, Italy; Hofrath von Konkoly, Hungary; M. Vincent, Belgium; Capt. Ryder, Denmark; and Messrs. P. Alexander and C. J. P. Cave, Great Britain. A number of interesting papers were read by various members of the Congress, and we learn from *Nature* that at the last meeting the following resolutions were adopted :—

1. Prof. Köppen's proposal to adopt absolute measures for atmospheric pressure was referred to the International Meteorological Committee. [See *Quarterly Journal*, April 1909, p. 132.]

2. The July series of observations to be made at 7 A.M. Greenwich mean time, and pilot balloons to be sent up three times a day in accordance with the proposals of Prof. Bjerknes.

3. M. Vincent's proposal that frequent observations of the state of the sky should be made on international days was recommended.

4. The importance of observatories for the study of the upper air to be urged on all countries which do not possess them.

5. M. de Massani's project to establish an upper-air observatory on the plains of Hungary, near Kecskemet, was endorsed.

6. It was resolved to bring to the notice of aero clubs the importance of observations during ascents of manned balloons for sport, etc.

7. Copies of traces of registering instruments are to be exchanged between members of the commission if required.

8. Titles of new publications to be sent to Prof. Assmann for publication and analysis in *Fortschritte der Physik* or to the U.S. Weather Bureau for the *Monthly Weather Review*.

9. Prof. Rotch's proposition to express the temperature gradient as positive when the temperature decreases with altitude was adopted.

10. Prof. Rotch's proposal that in the published observations of kite ascents simultaneous observations at ground level be given was adopted.

11. The thanks of the commission to be sent to the Spanish Government for its promise to establish an observatory on the Peak of Teneriffe, and to the Spanish military aeronauts and to the German Government for aiding the project.

13. Various new members were elected—MM. Trabert, Vincent, Kleinschmidt, Bjerknes, Ryder, and Bamier; the directors of the observatories of Irkutsk, Tiflis, and Ekaterinburg; and several military aeronauts, including Colonel Capper.

14. It was resolved that the next meeting of the commission should be held in Vienna in the autumn of 1912.

Fiji Rainfall.

Mr. R. L. Holmes reports that the rainfall at Delanasau, Bua, lat. 16° 38′ S., long. 178° 37′ E., in 1908, was as follows :—

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1908.	Ins.	Days.
January	13·46	15
February	12·30	21
March	18·23	15
April	7·45	19
May	5·02	18
June	0·85	8
July	2·22	5
August	1·84	7
September	2·68	7
October	2·11	11
November	8·23	17
December	5·05	7
Year	79·44	150

The total rainfall in 1908 was slightly below that of the previous year. In 25 years to the end of 1895 the yearly average was 99·03 ins., but in the following 13 years the average was 75·0 ins. The average fall for the 38 years was 90·82 ins.

Greatest fall was 159·51 ins. in 1871, and the least fall was 50·86 ins. in 1905.

The heaviest fall in one day was 14·95 ins. on March 20, 1871. In eight days, ending April 5, 1893, the fall was 42·86 ins. The average number of rain days in the 38 years was 154.

As regards the part of Fiji where most rain falls, it is uncertain, but the following cannot be far out.

Mr. James Newall started a plantation in 1875 at Q ra Walu, on Taviuni, south, 2½ miles from the sea, 564 feet above mean sea-level, and he sent me particulars of the climate. The rainfall in 1876 was 243·07 ins. on 236 days, and in 1877, 251·57 ins. on 288 days. This excess is caused by the trade winds blowing on to the high hills, moisture laden from the southern ocean. Mr. Newall found the climate too moist, so gave up the plantation experiment.

The year 1908 was on the whole a calm one as regards storms.

On January 4 the barometer fell to 29·518 ins. South of the island very stormy weather prevailed at that time.

On April 30 there was a remarkable electric storm with heavy rain, but little wind from the North. The flashes of lightning and the roar of thunder were terrific, particularly when the lightning struck and killed five cocoa-nut trees within 30 yards of our house.

Mr. G. C. Barrat, manager of the tea, cocoa, and rubber estate at Wainunu (south side of Vanua Levu, about 20 miles from Delanasau), has furnished the following particulars for 1908 :—

1908.	Rainfall ins.	Mean Temp. °
January	29·02	80·7
February	19·61	85·6
March	14·11	80·8
April	31·34	78·3
May	15·63	77·1
June	3·38	73·3
July	4·37	73·1
August	9·37	75·7
September	3·11	73·3
October	7·30	76·0
November	10·64	77·3
December	5·98	78·6
Year	153·86	77·5

The heaviest rainfall in one day was 8·75 ins. on May 13. The average rainfall for 29 years was 150·22 ins.

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Storm in 1638 in Devon.

Lysons in his *Magna Britannia* [Devonshire, p. 557] gives some account of this, and also mentions that a tract upon the subject, *A True Relation, etc.*, is reprinted in the *Harleian Miscellany.*

In the parish church of Widdecombe a curious record of the storm is still extant, written by a person who was present at the time. It is in verse.

Ernest Law on the Trees in Bushey Park.

The following extract from the pen of so competent a writer on the subject as Mr. Law may be of interest to many of our readers:—

"Entering the avenue at the Teddington Gate one sees at once on the left the result of the great storm of June last year [1908], which in a moment levelled *eighty* of the great trees. No such storm ever struck this avenue before, except the extraordinary one of November 1703,[1] rendered classical by Addison's allusion to it in his 'Campaign' (in the famous comparison of Marlborough to an angel riding in the whirlwind, 'Such as of late o'er pale Britannia passed').

"The damage then done in Bushey Park was enormous, but as the trees had been planted only four years it was easily made good.

"Not so that of last year, the traces of which will be manifest a century hence!"—*The Times*, May 31, 1909.

Meteorological Text-Books.

The U.S. Weather Bureau has published a *Brief List of Meteorological Text-Books and Reference Books*, which has been prepared by Mr. C. F. Talman, the librarian. This compilation is designed, primarily, to guide the librarians of large general, scientific, and university libraries in the United States in selecting meteorological literature for their collections. It is also intended to provide a ready means of complying with the many requests received by the Weather Bureau from teachers, students, and others for the titles of books dealing with meteorology and its several branches. This pamphlet, which contains the titles of about 150 works, is likely to be of service to American readers and students. It is, however, not by any means complete, as a number of English books and memoirs are not included.

A list of some of the works on meteorological subjects which English readers may consult with advantage will be found in the recently published second edition of *Some Facts About the Weather.*

RECENT PUBLICATIONS.

A Guide to the Natural History of the Isle of Wight. Edited by FRANK MOREY, F.L.S. Newport, Isle of Wight, 1909. 8vo. xx + 560 pp. Plates and Map.

This contains a series of contributions by specialists relating to the various branches of Natural History and kindred subjects. Mr. J. Dover contributes an article on Meteorology, in which he gives the results of his observations made at Totland Bay; and Miss M. Gibson gives the results of observations made at the Royal National Hospital, St. Lawrence, Ventnor, during the 20 years 1887-1907.

[1] Known as "The Great Storm."

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Observations and Investigations made at the Blue Hill Meteorological Observatory, Massachusetts, U.S.A. Under the direction of A. LAWRENCE ROTCH. [Annals of the Astronomical Observatory of Harvard College.] 4to. Cambridge, 1908-1909.

Part 3 of vol. 58 contains the observations made at Blue Hill, and at the lower stations; the observations of the upper air with kites during the year 1905; and summaries of the observations at the ground during the preceding lustrum and the 20 years. Mr. H. H. Clayton gives a report on the meteorology of total solar eclipses, including the eclipse of 1905, and Mr. A. L. Rotch gives a brief report on the eclipse shadow bands. The volume ends with a bibliography relating to the Blue Hill Observatory between 1901 and 1905. This list includes not only the writings of the staff on meteorological subjects wherever published, but also all references to them, or original articles about the Observatory by others, which have been discovered in books or scientific journals.

Part 3 of vol. 68 is devoted entirely to reports by Mr. H. H. Clayton and Mr. S. B. Fergusson on the exploration of the upper air by means of ballons-sondes at St. Louis, in the years 1904-7, and with kites at Blue Hill.

Observing and Forecasting the Weather. Meteorology without Instruments. By D. W. HORNER, F.R.Met.Soc. Second Edition, 1909. London: Witherby and Co. 6d. net. 8vo. 48 pp. and 3 plates.

The object of the author in publishing this treatise, which has now reached its second edition, has been that the ordinary individual may have a cheap and easily understood book, by means of which he may quickly acquire some knowledge of the science of the weather, and become more or less expert at weather forecasting. As the author considers there are many works treating of instrumental observations, he has confined his remarks entirely to "non-instrumental observations," a subject which he considers can be taken up without any expense or outlay whatever by any one of average intelligence.

The subjects dealt with are "Clouds," "Wind," "Halos and kindred Phenomena," "Thunderstorms," "Weather Sayings," "The Moon and the Weather," and "Phenological Observations."

Solar Physics Committee. A Discussion of Australian Meteorology. By WILLIAM J. S. LOCKYER, M.A., Ph.D. Under the direction of Sir NORMAN LOCKYER, K.C.B., F.R.S. London, 1909. 4to. vii + 117 pp. and 10 plates.

The previous memoir published by the Solar Physics Committee, *Monthly Mean Values of Barometric Pressure for 73 Selected Stations*, contained a number of curves representing the pressure changes over Australia from year to year, which indicated a variation of about four years' duration, a period already found in India and South America, and corresponding with the curve of prominence frequency. In a subsequent paper to the Royal Society Dr. Lockyer referred again to this variation of the mean annual pressure values in operation in Australia, and directed attention to the fact that the mean amplitude of the Australian variation was nearly double that of the Indian change. He further showed that this Australian pressure change amounted to nearly 35 per cent. of the mean annual variation, and must therefore play an important part in bringing about changes in the weather experienced from year to year. In the case of the pressure variation of long duration in operation in Australia, he pointed out also that this fluctuation took about 19 years to complete a cycle, and its amplitude reached nearly 25 per cent. of the annual variation.

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The importance of these changes, their possible periodicity, and their extensive distribution, suggested that a more detailed inquiry into the meteorology of Australia as a whole might be useful, and such an investigation is now presented by Dr. Lockyer in the present memoir.

This commences with a brief account of the similar barometric changes which occur over the whole of Australia from year to year, and then a general survey of the main features of Australian meteorology is given. The mean annual pressure and rainfall variations are next individually dealt with and compared in order to determine their seasonal distribution. A comparison is then made with the changes from year to year of the pressure and rainfall, and here also are brought together some deductions with regard to the frequency of "southerly bursters." The variations in the heights of the river gauge readings, situated on the Darling and Murray rivers, are also brought in as evidence to corroborate the rainfall changes. A summary is given of the results obtained from the data employed to determine changes of long duration from barometric and rainfall statistics. The relation of Australian pressure changes to variations in other parts of the world, chiefly South America, South Africa, and India, is then discussed, and some facts are brought together in which an attempt is made to point out the similarity of air movements over South America, South Africa, the South Indian Ocean, and Australia.

The whole discussion is based chiefly on the comparison of curves, but the data from which they have been made are given in detail in the Appendix for reference.

Some Facts about the Weather. A Popular Meteorological Handbook. By WILLIAM MARRIOTT, F.R.Met.Soc., Assistant Secretary and Lecturer of the Royal Meteorological Society. Second and Revised Edition. London: E. Stanford, 1909. Price Sixpence. 8vo. 37 pp.

This cheap little handbook, which is published under the authority of the Royal Meteorological Society, has been written to convey in a popular form most of the leading facts about the weather which apply to the British Isles. The second edition has been revised and extended and brought up to date. The subjects dealt with are:—Weather Sayings, Meteorology, Climate and Weather, Instruments for observing Weather, Temperature, Atmospheric Pressure, Wind, Moisture, Cloud, Rain, Snow, Hail, Lightning, Thunderstorms, Sunshine, The Upper Air, Weather Charts, Vegetation, Records of Phenomena, Books and Publications on Meteorology, and Royal Meteorological Society.

The work contains numerous maps, charts, and illustrations of meteorological phenomena.

Untersuchungen über die Schwankungen der Niederschläge. Von G. HELLMANN. [Veröffentlichungen des Königlich-Preussischen Meteorologischen Instituts, Nr. 207. Abhandlungen, Bd. III., Nr. 1.] Berlin: Behrend & Co., 1909. 4to. 81 + 28 pp. Price 9 marks.

An elaborate memoir on the fluctuations of rainfall dedicated by Dr. Hellmann to Prof. Dr. Julius Hann on the occasion of his seventieth birthday, March 23, 1909. The author has collected the rainfalls from a number of stations with long records in various parts of Europe, and gives the average monthly and annual rainfall for the 50 years 1851-1900, from 42 stations. The monthly amounts of rainfall are given for the 55 years 1851-1905, together with the average values for the 50 years 1851-1900, for 28 European stations. Dr. Hellmann makes a very full discussion of the rainfall.

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METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of more general interest.

Abbe, C.—The Progress of Science as illustrated by the Development of Meteorology. *Smithsonian Report*, **1907**. *Washington*, 1908 (287-309).

Alt, E.—Die Doppeloszillation des Barometers, insbesondere im arktischen Gebiete. *Meteor. Zeits., Brunswick*, **26**, 1909 (145-164).

Alton, C. D.—Climate and Hay-Fever. *Trans. Amer. Clim. Ass., Philadelphia*, **24**, 1908 (20-28).

Arctowski, H.—Les variations séculaires du climat de Varsovie. *Prac. matematyczno-fizycznych, Warszawa*, **19**, 1908 (183-206).

Arendt, T.—Ergebnisse zehnjähriger Gewitterbeobachtungen in Nord- und Mitteldeutschland. *Abhandl. der Kön.-Preuss. Met. Inst.*, **2**, No. 2, *Berlin*, 1908.

Assmann, R.—Beiträge zum Klima von Norderney. *Aus dem Archiv, Hamburg*, **31**, 1908, No. 3.

Assmann, R.—Professor Dr. Adolf Sprung. *Wetter, Berlin*, **26**, 1909 (25-27).

Bernacchi, L. C.—Results of some Physical Observations taken on the National Antarctic Expedition, 1902-1904. *Rep. Brit. Assoc.*, **1908**, *London*, 1909 (645-647).

Bigelow, F. H.—Studies on the Vortices of the Atmosphere of the Earth. *Monthly Weather Rev., Washington*, **36**, 1908 (398-404).

Bonacina, L. C. W.—The Seasons and their Definition. *Symons's Met. Mag., London*, **44**, 1909 (28-31).

Boutquin, A.—L'Asie centrale. *Ciel et Terre, Brussels*, **29**, 1909 (587-598, 615-625), **30**, 1909 (1-7, 41-48, 57-63, 105-113, 129-140).

Bowman, I.—Man and Climatic Change in South America. *Geog. J., London*, **33**, 1909 (267-278).

Brazier, C. E.—Les recherches sur l'évaporation entreprises aux États-Unis. *Ann. Soc. Mét. de France, Paris*, **57**, 1909 (41-45).

Brodie, F. J.—The Weather during the Agricultural Year 1907-1908. *J. R. Agric. Soc., London*, **69**, 1908 (384-398).

Browning, C. C.—The Effect of Climatic Conditions on Important Symptoms in Tuberculosis. *Trans. Amer. Clim. Ass., Philadelphia*, **24**, 1908 (10-14).

Brunhes, B.—L'Observatoire du Puy de Dôme depuis 1876. Reprinted from *Association française Clermond-Ferrand*, **1908**.

Butcher, Dorothy D.—Experiments on Artificial Fulgurites. *Proc. Phys. Soc., London*, **21**, 1909 (254-260).

Coronas, Rev. J.—The Hongkong Typhoon, July 21-29, 1908. *Bull. Weather Bureau, Manila*, **1908**. Manila, 1909 (204-215).

Craig, J. I.—A Meteorological Expedition to Addis Abbaba in 1907. *Reprinted from the Cairo Scientific Journal*, No. 27, 1908.

Craig, J. I.—The Climate of Ancient Palestine. *Reprinted from the Cairo Scientific Journal*, No. 27, 1908.

Day, F. H.—Deficient Humidity Indoors. *Monthly Weather Rev., Washington*, **36**, 1908 (404-407).

Defant, A.—C. Alessandri, Messungen der Intensität der Sonnenstrahlung auf dem Monte Rosa. *Meteor. Zeits., Brunswick*, **26**, 1909 (54-60).

Devereux, H. B.—The Cyclone and Floods of January 1907 in New Zealand. *Symons's Met. Mag., London*, **44**, 1909 (36-37).

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Dines, J. S.—The Results of the ballons-sondes Ascents in the British Isles during the International Week, July 27 to Aug. 1, 1908. *Rep. Brit. Assoc.*, **1908**, *London*, 1909 (642-644).

Discussion on the Isothermal Layer of the Atmosphere. *Rep. Brit. Assoc.*, **1908**, *London*, 1909 (591-594).

Discussion on the Theory of Wave Motion. *Rep. Brit. Assoc.*, **1908**, *London*, 1909 (605-611 and pl.).

Eckardt, W. R.—Der Einfluss des Waldes auf das Klima. *Deutsch. Meteor. Jahrb.*, **1907**. · *Aachen*, 13, Karlsruhe, 1908 (55-61).

Ekholm, N.—Om lufttryckets ändringar och därmed sammanhängande företeelser. *Ymer, Tidskrift af Svenska sällskapet för antropologi och geografi*, **1908** (345-406).

Eliot, Sir J.—Discussion of the Anemographic Observations recorded at Sangor Island from March 1880 to February 1904. *Indian Met. Mem., Calcutta*, **18**, 1909 (123-214 and 16 pl.).

Eliot, Sir J.—Discussion of the Anemographic Observations recorded at Alipore (Calcutta) from March 1877 to February 1904. *Indian Met. Mem., Calcutta*, **18**, 1909 (215-282 with 14 pl.).

Eliot, Sir J.—A Discussion of the Anemographic Observations recorded at Pachmarhi from September 1883 to April 1887. *Indian Met. Mem., London*, **19**, 1908 (1-63 and 14 pl.).

Eliot, Sir J.—A Discussion of the Anemographic Observations recorded at Nagpur from January 1882 to December 1902. *Indian Met. Mem., London*, **19**, 1908 (65-139 and 15 pl.).

Eredia, F.—Sulla temperatura osservata negli Osservatori Astronomici del Collegio Romano e del Campidoglio e nella Stazione Meteorica della Direzione di Sanità dal 1898 al 1907. *Rivista Meteorico-Agraria, Roma*, **30**, 1909 (89-97).

Eve, A. S.—Some Problems in Radioactivity. *Terrestrial Magnetism, Baltimore*, **14**, 1909 (25-36).

Everdingen, E. van.—Über die Ermittelung des Winkels zwischen Gradient und Windrichtung. *Meteor. Zeits., Brunswick*, **26**, 1909 (75-78).

Exner, F. M.—Neue Strahlungsuntersuchungen aus dem astrophysikalischen Observatorium der Smithsonian Institution. *Meteor. Zeits., Brunswick*, **26**, 1909 (120-129).

Field, J. H.—Kite Flights in India and over the Neighbouring Sea Areas during 1907. *Indian Met. Mem., Calcutta*, **20**, 1908 (125-139 and 6 pl.).

Fisk, S. A.—A Search for a Suitable Climate. Part 2. *Trans. Amer. Clim. Ass., Philadelphia*, **24**, 1908 (15-19).

Forch, C.—Wind und Strom im Golf von Mexiko und seinen Verbindungsstrassen mit dem Atlantischen Ozean. *Ann. d. Hydrog. Marit. Met., Berlin*, **37**, 1909 (172-175).

Gold, E.—The Isothermal Layer of the Atmosphere and Atmospheric Radiation. *Proc. Roy. Soc., London, A.*, **82**, 1909 (43-70).

Gregg, W. R.—Auroral Displays and Magnetic Disturbances at Mount Weather during September 1908. *Bull. Mount Weather Observatory, Washington*, **2**, 1909 (19-23).

Grossmann, Prof.—Dr. Ernst Kohlschütter: Höhenmessungen in Deutsch-Ostafrika. *Meteor. Zeits., Brunswick*, **26**, 1909 (67-74).

Hamburg, Deutsche Seewarte.—Versuch mit Wetter-Funkentelegrammen vom Nordatlantischen Ozean. *Ann. der Hydrog. Marit. Met., Berlin*, **37**, 1909 (49-51).

Hamburg, Deutsche Seewarte.—Übersicht über die in den letzten 30 Jahren bei der deutschen Seewarte eingelieferten meteorologischen Schiffstagebücher. *Ann. der Hydrog. Marit. Met., Berlin*, **37**, 1909 (97-100).

Hellmann, G.—Untersuchungen über die Schwankungen der Niederschläge. *Abhandl. der Kön.-Preuss. Met. Inst.*, **3**, No. 1, *Berlin*, 1909.

Hesketh, W. T.—Our Diminishing Rainfall. *Manchester Guardian*, March 9, 1909.

Hoffmann, J. F.—Die Veränderungen des Grundwasserstandes und die Volgersche Theorie. *Wetter, Berlin*, **26**, 1909 (49-60).

Hubbard, G.—Dew-ponds. *J. Roy. Soc. of Arts, London*, **57**, 1909 (330-336).

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Humphreys, W. J.—Vertical Temperature Gradients of the Atmosphere, especially in the Region of the Upper Inversion. *Bull. Mount Weather Obsy., Washington*, **2**, 1909 (1-18).

Joester, K.—Die Föhnerscheinungen im Riesengebirge. *Wetter, Berlin*, **26**, 1909 (36-39, 60-62).

Jones, J. R. G.—Snowdonia's August Floods. *Symons's Meteor. Mag., London*, **44**, 1909 (53-54).

Köppen, W.—Drei Jahre gleichzeitiger meteorologischer Drachenaufstiege bei Hamburg, Berlin und St. Petersburg. *Aus dem Archiv, Hamburg*, **31**, 1908, No. 1.

Lagrange, E.—Le Pôle magnétique sud et la variation diurne de la déclinaison. *Ciel et Terre, Brussels*, **29**, 1909 (572-574), **30**, 1909 (17-22).

Lagrange, P.—La pluie et le régime des cours d'eau en Limousin en 1908. *Ann. Soc. Mét. de France, Paris*, **57**, 1909 (14-15).

Leyst, E.—Luftelektrische Beobachtungen im Ssamarkand'schen Gebiet während der totalen Sonnenfinsternis am 14. Januar 1907. *Bull. Soc. Imp. des Natur., Moscow, n.s.*, **21**, 1908 (493-528).

Leyst, E.—Meteorologische Beobachtungen in Moskou im Jahre 1907. *Bull. Soc. Imp. des Natur., Moscow, n.s.*, **21**, 1908 (552-591).

Lindemann, A.—Die grössten Tagesmengen des Niederschlages im Königreich Sachsen von 1866 bis 1905. *Wetter, Berlin*, **26**, 1909 (32-36).

Lockyer, W. J. S.—Cloud Photographs from a Balloon. *Nature, London*, **80**, 1909 (310-311).

Lockyer, W. J. S.—Erroneous Photographs of Lightning Flashes. *Knowledge, London*, **6**, 1909 (177-181).

Lüdeling, G., und Nippoldt, A.—Die Expedition des Königlich-Preussischen Meteorologischen Instituts nach Burgos in Spanien zur Beobachtung der totalen Sonnenfinsternis am 30. August 1905. *Abhand. der Kön.-Preuss. Met. Inst.*, **2**, No. 6, *Berlin*, 1908.

Maillet, E.—Résumé des observations centralisées par le service hydrométrique du Bassin de la Seine pendant l'an 1907. *Ann. Soc. Mét. de France, Paris*, **56**, 1908 (285-297).

Maillet, E.—Sur la durée de la propagation des maxima des crues et sur diverses formules des annonces de crues dans le bassin de la Seine. *Ann. Soc. Mét. de France, Paris*, **57**, 1909 (10-13).

Maurer, J.—Aus langjährigen Aufzeichnungen des Schweizer Föhns. *Meteor. Zeits., Brunswick*, **26**, 1909 (165-170).

Mémery, H.—Phénomènes solaires et phénomènes sismiques. *Ann. Soc. Mét. de France, Paris*, **57**, 1909 (46-52).

Miethe, A., and Lehmann, E.—Dämmerungsbeobachtungen in Assuan im Winter 1908. *Meteor. Zeits., Brunswick*, **26**, 1909 (97-114).

[Mill, H. R.].—The Rainfall of March and of the Winter Half-Year. *Symons's Met. Mag., London*, **44**, 1909 (45-47).

Mill, H. R.—The Measurement of Rainfall. *Trans. Assoc. Water Eng.*, **13**, 1908, *London*, 1909 (175-198 and pl.).

Moidrey, J. de.—L'Observatoire magnétique de Zi-ka-wei. *Terrestrial Magnetism, Baltimore*, **14**, 1909 (1-2).

Moore, Sir J. W.—Is our Climate changing? *Rep. Brit. Assoc.*, **1908**. *London*, 1909 (623-625).

Oddone, E.—La seconde riunione della Commissione Permanente e la prima Assemblea Generale dell' Associazione Internazionale di Sismologia all' Aja dal 21 al 25 settembre 1907. *Boll. Soc. Sis. Ital., Modena*, **13**, 1909 (17-36).

Peppler, W.—Luftdruckstudien. *Wetter, Berlin*, **26**, 1909 (27-32).

Polis, P.—Wireless Telegraphy in the service of Modern Meteorology. *Monthly Weather Rev., Washington*, **36**, 1908 (407-408).

Polis, P.—Feuchtigkeitsmessungen auf dem Atlantischen Ozean. *Meteor. Zeits., Brunswick*, **26**, 1909 (90-92).

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Querfurt, H.—Die Einwirkung der Winde auf die Strömungen im Skagerrak und Kattegat mit besonderer Berücksichtigung der am Leuchtschiff *Skagens Rif* angestellten Beobachtungen während der Jahre 1903 bis 1905. *Ann. der Hydrog. Marit. Met., Berlin*, **37**, 1909 (107-121, 153-171, 208-223).

Rheden, J.—Wolkenhöhenmessungen mit Hilfe der Scheinwerferanlage des Wiener Leuchtbrunnens im Jahre 1908. *Meteor. Zeits., Brunswick*, **26**, 1909 (60-66).

Shaw, W. N.—Address to Section A. of the British Association, 1908. *Rep. Brit. Assoc.*, **1908**, *London*, 1909 (579-591).

Steen, A. S.—Einige Studien über die Bewölkung. *Meteor. Zeits., Brunswick*, **26**, 1909 (49-54).

Teisserenc de Bort, L., and **Rotch, A. L.**—General Results of the Meteorological Cruises of the *Otaria* on the Atlantic in 1905, 1906, and 1907. *Nature, London*, **80**, 1909 (219-221).

The International Commission for Scientific Aëronautics. *Nature, London*, **80**, 1909 (354-356).

The Movements of Ice in the North Atlantic Ocean, and their Influence on Navigation. *Pilot Chart of the North Atlantic Ocean, Washington*, April 1909.

The Snowfall of February to March, 1909. *Symons's Met. Mag., London*, **44**, 1909 (21-24).

Thorade, H.—Über die kalifornische Meeresströmung. Oberflächentemperaturen und Strömungen an der Westküste Nordamerikas. *Ann. der Hydrog. Marit. Met., Berlin*, **37**, 1909 (63-76).

Treibeis in südlichen Breiten. *Ann. der Hydrog. Marit. Met., Berlin*, **37**, 1909 (204-208).

Vincent, J.—Études sur les nuages. *Ciel et Terre, Brussels*, **30**, 1909 (33-40).

Wagner, A.—Die höchsten Registrierballonaufstiege. *Meteor. Zeits., Brunswick*, **26**, 1909 (88-90).

Walker, G. T.—Correlation in Seasonal Variation of Climate. *Indian Met. Memoirs*, **20**, *Calcutta*, 1909 (117-124).

Wedderburn, E. M.—Temperature Observations in Loch Garry (Inverness-shire), with Notes on Currents and Seiches. *Proc. Royal Soc., Edinburgh*, **29**, 1909 (98-135).

Williams, G. B.—The Geographical Distribution of the Mean Annual Rainfall of Wales and Monmouthshire. *Geog. J., London*, **33**, 1909 (297-305 and map).

Witting, R.—Zur Kenntnis des vom Winde erzeugten Oberflachenströmes. *Ann. der Hydrog. Marit. Met., Berlin*, **37**, 1909 (103-203).

Woeikof, A.—Temperatur ostsibirischer Flüsse und eines Polarsees daselbst. *Meteor. Zeits., Brunswick*, **26**, 1909 (114-118).

Woeikof, A.—Die meteorologische Station Vassijaure in schwedisch Lappland. *Meteor. Zeits., Brunswick*, **26**, 1909 (118-120).

Wundt, W.—Barometrische Teildepressionen und ihre wellenförmige Aufeinanderfolge. *Abhandl. der Kön.-Preuss. Met. Inst.*, **2**, No. 5, *Berlin*, 1904.

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November	7.30 p.m.	17, 1909	March	7.30 p.m.	16, 1910
December	„	15, „	April	„	20, „
January	„	19, 1910	*May	4.30 p.m.	18, „
February	„	16, „	*June	„	15, „

January 19, 1910.—Annual General Meeting.

The Meetings will be held at the Institution of Civil Engineers, Great George Street, Westminster, S.W., except those marked with an asterisk (*), which will be held at the Society's Rooms, 70 Victoria Street, S.W.

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THE ANTICYCLONIC BELT OF THE NORTHERN HEMISPHERE.

By Colonel H. E. RAWSON, C.B., R.E., F.R.Met.Soc.

[Read May 19, 1909.]

IN a previous communication[1] some facts regarding the anticyclonic belt of the southern hemisphere were brought to the notice of the Society, derived from an exhaustive examination, made on the spot, of South African records from the year 1841 to 1906. The conclusion drawn from them was that, short as the period examined was, the indications of a cyclical oscillation of the belt to and from the equator over South Africa were strong enough to encourage the belief that an analysis of Australian records on the one side, and of Argentine on the other, would prove that the movements of all the action-centres of the atmosphere were related to one another over this wide area, and that a similar oscillation existed in the northern hemisphere. The barometric variations, the excess and deficiency of rainfall, the changes in the percentage frequency of the winds, which had been recorded both at the Cape Town and Durban Observatories, supported as they were by numerous isobaric charts, all pointed to the years 1884 and 1893 as those in which the belt was at the southern and northern extremities respectively of its swing, and to the existence of a cycle with a period of 19 years. Mr. H. C. Russell's investigations into the good and bad seasons of New South Wales which favoured such a cycle for the years 1872-96 were quoted, but owing to the lack of all books of reference on the subject during my absence in South Africa, I made no allusion to his later and much more complete paper "On Periodicity of Good and Bad Seasons," which he read before the Royal Society of New South Wales in June 1896. I was in fact quite unaware of it, or I should have called attention to the strong

[1] *Quart. Journ. Roy. Met. Soc.* **34**, 1908, p. 165, "The Anticyclonic Belt of the Southern Hemisphere."

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support it afforded to the conclusions drawn by me from the South African records.

Extension of the Inquiry to Australia and South America.

In that paper[1] Mr. Russell has definitely stated that, after carefully examining the particulars of the weather in the colony from all sources, for each year of its history, and classifying the years as good or bad, that is as having sufficient or insufficient rainfall, he found that during the previous 108 years, since the colony was founded, droughts had recurred at regular intervals of exactly 19 years. Moreover, in each period of 19 years there had been two periods of drought which were most regular and cyclical in their recurrence, and lasted from 3 to 7 years. Taking the second year of the three as the centre of the group, he compiled a list of all the droughts in New South Wales which had occurred.

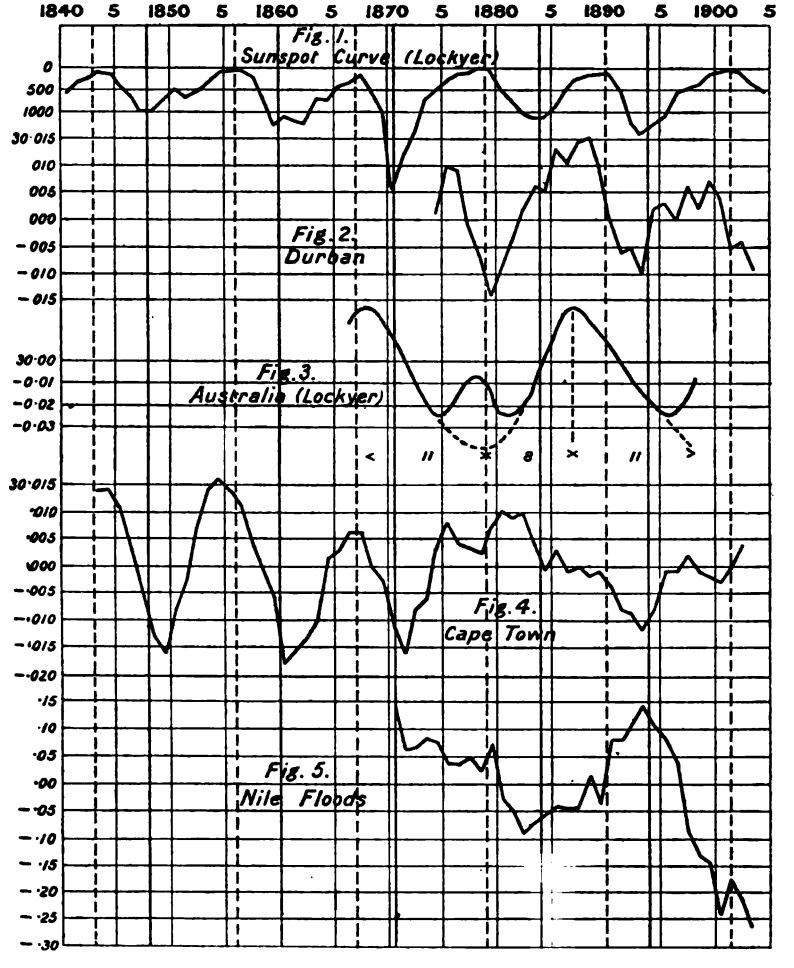
The most intense droughts, which he termed the A series, are seen to have a 19-year period dating from 1885, and the next important, or the D series, a similar period dating from 1895. Observe the dates. The droughts which I had traced over latitudes 31°-34° S. in South Africa, and had explained by the belt hanging over the district while at the extreme southern end of its range, had a 19-year period dating from 1884. New South Wales lies almost entirely between latitudes 29°-36° S., and if the belt of the southern hemisphere oscillates to and from the equator over Australia in the same way as it appears to do over South Africa, it would have been hanging over New South Wales also in 1884, and have commenced to return in 1885 over a district already partly desiccated by its previous passage southwards. Such an explanation of the principal A series of droughts would then be the same as that given by me for the droughts in the south-west of the African Continent, which also lasted 3 to 5 years, and they recur in the same years. If the range of the belt in latitude over Australia is similar to that over South Africa, its central axis would be two degrees to the north of New South Wales, when it was in its most northerly position in 1893. New South Wales would then be not so completely under the influence of the belt, and it would not be till a year later that it would be once more fully experiencing anticyclonic conditions. The facts given by Mr. Russell completely bear out such a theory, for he found that the droughts of the D series were not so intense as those of the A series, nor did they last so long, and the year he dates the series from is 1895 and not 1894.

Dr. J. W. S. Lockyer has made a special examination of the Australian barometric records in connection with his study of the pressure variations of long duration over large areas of the globe, and has followed up in a special paper the idea of a barometric see-saw existing between India, Australia, and South America.[2] He has published curves to illustrate the pressure changes of short duration (which he has found at a great many stations average about 4 years) occurring in the Australian area. The records of Melbourne (lat. 37° 46′), Adelaide (lat. 34° 58′), Sydney

[1] *Proc. Roy. Soc. New South Wales*, 1896.
[2] *Roy. Soc. Proc.* 78, 1906, p. 43.

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(lat. 34°), and Perth (lat. 31° 56′) are plotted for each year, and the curves obtained are in addition smoothed so as to eliminate the 4-year variation, after the manner always adopted by Dr. Lockyer in these investigations. In order to make a closer comparative study of the variations of Australia and South America, he has drawn a hypothetical curve embodying the main features of the pressure changes at these



FIGS. 1-5.—Curves to illustrate the Pressure and Nile Flood Changes of Long Duration after elimination of the 4-year variation. The thick continuous and dotted vertical lines denote the epochs of sunspot maxima and minima as determined from the mean daily areas of both hemispheres of the sun.

stations, to indicate in a single curve the general nature of the variations in that area as regards their epochs of maxima and minima. He summarises his conclusions as follows: "The epochs of the two principal maxima for the Australian area are seen to occur at about 1868 and 1887, while three subsidiary maxima are suggested at about the years (1858 ?),

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1878, and (1898 ?), but the epochs of the first and last of these are very uncertain, as the curves do not extend over a sufficiently long period of time. Nevertheless, it may here be remarked that the interval between the two chief maxima is 19 years, while those between the successive secondary maxima are about the same length." I have reproduced in Fig. 3 Dr. Lockyer's hypothetical curve in which the 19-year intervals between the chief maxima about 1868 and 1887, and between the secondary maxima about 1878 and 1898, are shown. In Fig. 1 I have plotted Dr. Lockyer's sunspot curve, and in Fig. 2 barometric means to illustrate the pressure curve for Durban, eliminating the 4-year variation by the process he adopts.[1] The principal maximum, which appears in 1887 and 1888, and gives to the curve a striking resemblance to the Australian hypothetical curve, is also accompanied by two subsidiary maxima in 1875-6 and 1899, and I am of opinion that the cause must be the same in both cases. But in that of the Durban barometric variations and the accompanying changes in rainfall, I attributed the record pressure in 1887, with its deficient rainfall, to the position of the belt over Natal during that year; while in the years 1878 and 1899 it was again passing over this area, and bringing high pressure and drought to Durban in its cyclical march to and from the equator. In 1899 the mean annual pressure was the second highest, after 1887, which has ever been recorded at Durban Observatory. The rainfall records for 1878 and 1899 were the two lowest.[2]

I submit, therefore, that the maxima in the two curves are due to one and the same cause; and having found reason to believe that in the case of South Africa they were due to the belt passing to and fro over the district, we are justified in thinking that in that of Australia they are due to it oscillating over New South Wales in the same years. The principal maxima synchronised with its passage from its most southern position on its way towards the equator, and the subsidiary maxima with that from the equator to the pole. Whether any significance is to be attached to this must be decided by future investigation. The time-phase is practically the same for both Durban and Australia, but it is clear that the latitudes of the places Dr. Lockyer examined require to be taken into consideration. He has referred in his paper to the detection by Mr. Russell of a 19-year period of rainfall change, but he claims that the long *barometric* swing of 19 years in Australia had not previously been pointed out. He states that so far as his research has gone no explanation can be found of the cause of this pronounced 19-year pressure variation, but that there seems evidence to suggest that it is due to solar action modified by some terrestrial cause. If the oscillation of the Australian high-pressure system belonging to the southern anticyclonic belt is proved to be taking place, as I ventured to suggest it would be before I became aware, owing to my absence in South Africa, of Dr. Lockyer's investigations, all the above facts are readily explained.

[1] To eliminate as far as possible the prominent short variations which appear in so many curves, Dr. Lockyer groups the years in sets of four, and employs the mean values of each group, plotting the value thus obtained at the end of the second year of the group of which it is the mean. Fig. 2 is drawn to the same scale as his plates. Throughout this discussion the references are chiefly to these curves, and not to those which are not smoothed.

[2] Unfortunately there was a change of stations at which the Durban observations were taken, and it is only since 1884 that they have been made at the Observatory.

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The cause of the oscillation remains, however, to be considered on some future occasion.

In addition to Dr. Lockyer, Mr. D. E. Hutchins, who is well known for the part he is taking in endeavouring to connect the pressure-variations of South Africa with those of India, has examined the barometric records of some of the Australian stations. I referred in my previous paper to his exhaustive investigations, which he published in 1889, regarding droughts and good seasons in South Africa.[1] While endeavouring to trace the Sunspot Cycle in the meteorology of South Africa he was unable to coax into it, as he says, even by "irregular mitigations" or "cyclical mitigations," certain very pronounced cyclical phenomena found occurring on the Atlantic side of the continent. There was a secondary cycle, associated with low readings of the barometer, and with floods and storms, to which he gave the name of the Storm Cycle, which quite obliterated the Sunspot Cycle. It reckoned back correctly for seven cycles with a period of 9·5 years, or if an old date in Cape history, 1652, were included, when the rare phenomenon of snow on Table Mountain occurred similar to 1888, the more precise value of 9·43 years could be assigned to it. He traced the appearance of the Cape Storm Cycle in the Mauritian rainfall, and then extending his inquiry to Australia he examined some of its barometer records. He summed up his conclusions in the following words: "This fragment of the meteorological records from Adelaide follows so closely the cycles of an eastern station near the coast of South Africa" [notice the question of latitude contained in this] "that I have no hesitation in predicting that an extended examination of Australian stations will show a cyclical variation of climate almost identical with that of South Africa." His cycle was one of 9·5 years, and not 19 years.

Dr. Lockyer has also examined the barometric records of South America in the course of his study of the barometric variations of long duration over large areas. He has constructed curves to illustrate the pressure changes at Santiago (lat. 33° 30′), San Juan (lat. 31° 30′), Cordoba (lat. 31° 25′), Goya (lat. 29° 7′), and Curityba (lat. 25° 20′), and has deduced from them a hypothetical curve for South America by a similar process to that adopted for Australia. Its two principal maxima are seen to occur in 1874 and 1893, again indicating the existence of a 19-year interval. These years are identical with those in which, according to my analysis, the belt reached its most northerly position across South Africa, and ought, according to the theory advanced, to be affecting these districts of South America. Looking at the latitudes of the stations whose records he examined, especially that of Cordoba, which is such an important place in all his investigations, we cannot but conclude that they are near the position occupied by the belt when it is nearest to the equator, and that in this case, as in those of Australia (Fig. 3) and Durban (Fig. 2), the American curve, with its principal and subsidiary maxima, is to be explained in exactly the same way, viz. by the cyclical oscillation of the southern belt.

Corroborative evidence can also be drawn from Russell's paper. Amongst the droughts which he found to have occurred in the southern hemisphere at the same epochs as those of the A series in New South Wales (which have been identified with the southern position of the belt in this

[1] *Cycles of Drought and Good Seasons in South Africa*, by D. E. Hutchins, 1889.

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paper), he has described two as having been exceptionally severe over the Argentine Republic: one in 1885, and another in 1827-8-9, which is still spoken of as "Il gran seco," and lasted all these years over the Pampas and the Chaco of La Plata, and especially affected the northern part of Buenos Ayres and the southern part of Santa Fé (*i.e.* the districts between lats. 33° and 36° S., or south of the region included in Dr. Lockyer's inquiry). Darwin, who arrived in H.M.S. *Beagle* in 1832, gives a graphic account of the sufferings of live-stock during this long drought, and concludes by saying: "These droughts to a certain degree seem to be almost periodical; I was told the dates of several others, and the intervals were about 15 years." If a period of 3 to 4 years is allowed for the duration of these exceptional droughts, an interval of 15 years would point to their recurrence each 19 years, and these historical droughts of 1885 and 1828 would be explained by the belt persisting over these latitudes of South America while at the extreme southern end of its swing, just as in the cases of South African and Australian droughts. Buenos Ayres, Monte Video, Cape Town, and Sydney are all very nearly situated on lat. 34° S.

If it is considered that Dr. Lockyer, Mr. Russell, and myself approached this inquiry from very different standpoints and quite independently, the agreement between the theory advanced and the facts that have been brought together is remarkable.

Extension of the Inquiry to the Northern Hemisphere.

The independent evidence in favour of the cyclical oscillation of the anticyclonic belt of the southern hemisphere is so strong that I am encouraged to extend the inquiry to the movements of the action-centres of the atmosphere in the northern hemisphere with a view to ascertaining whether they show any similar oscillation to and from the equator, which is not to be explained by seasonal changes of position. Evidences of the existence of some kind of oscillation have been previously detected in the varying paths followed in successive years by the so-called permanent anticyclonic systems.[1] The question now before us becomes, Is a similar oscillation traceable over large areas of the northern hemisphere, and is it possible to determine, in spite of the unstable conditions which exist there, whether it is of like or unlike phase to that in the southern? If the oscillation is of like phase the high-pressure systems composing the northern belt will be found moving away from the equator as the southern belt moves towards it, and *vice versâ*; if it is of unlike phase, both belts will move together towards or away from the equator, in the same manner as I have pointed out the belts of Jupiter behave as that planet approaches or recedes from the sun.

To help us in this inquiry, we fortunately have ready to our hand the magnificent researches into barometric see-saws by meteorologists of all nations. In this country we have more particularly those of Sir Norman Lockyer and Dr. Lockyer, who have acknowledged, in their communications to the Royal Society,[2] their indebtedness to others where this was necessary. For the sake of brevity my references must be confined to

[1] *Quart. Journ. Roy. Met. Soc.* **24**, 1898, p. 180.

[2] *Proc. Roy. Soc.* **70**, 1902, p. 500; **71**, 1903, pp. 134, 244, 446; **73**, 1904, pp. 142, 457.

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their work alone on this occasion, my object in the present paper being to obtain a discussion of the facts which are brought to light by the investigation, and not to present a complete statement regarding the existence of barometric see-saws over the surface of the globe. Sir Norman and Dr. Lockyer have discovered the two standard and inverse types of pressure at Bombay and Cordoba, and in doing so, have enabled me to connect up the oscillation of the southern with that of the northern belt, the result of which I now proceed to put before the Society.

TABLE I.—Ratios of Annual Nile Floods to Mean Flood, and Pressure Anomalies in North-East Africa, 1865-1905.

1st Series.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	Remarks.
Floods	1·18	1·23	1·05	1·11	0·84	1·26	1·10	1·09	0·70	1·25	1·14	In excess.
Pressure Anomaly mm.	−0·67	−0·12	−0·49	−0·49	+0·43	+0·36	−0·14	+0·16	+0·91	−0·86	−1·15	Deficient.
Pressure Anomaly ins.	−·026	−·005	−·019	−·019	+·017	+·014	−·006	+·006	+·036	−·034	−·065	

2nd Series.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.			Remarks.
Floods	0·98	0·93	0·84	1·04	0·83	0·99	0·91	1·19	0·72	...	...	Deficient.
Pressure Anomaly mm.	+0·11	+0·11	+0·60	+0·39	+0·95	+0·02	+0·17	−0·47	−0·06	...	...	In excess.
Pressure Anomaly ins.	+·004	+·004	+·024	+·015	+·037	+·001	+·007	−·019	−·002	...	...	

3rd Series.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.		Remarks.
Floods	1·00	1·12	1·01	1·20	0·99	1·22	1·15	1·06	0·89	1·07	...	In excess.
Pressure Anomaly mm.	−0·45	−0·28	+0·42	−0·52	−0·22	−0·38	+0·33	+0·09	+0·06	−0·005	...	Deficient.
Pressure Anomaly ins.	−·018	−·011	+·017	−·020	−·009	−·015	+·013	+·004	+·002	...	...	

4th Series.	1899.	1900.	1901.	1902.	1903.	1904.	1905.					Remarks.
Floods	0·63	0·89	0·87	0·63	0·89	0·75	0·65	...	...	...	...	Deficient.
Pressure Anomaly mm.	+0·54	+0·30	−0·09	+0·11	+0·30	...	...	...	...	...	...	In excess.
Pressure Anomaly ins.	+·021	+·012	−·004	+·004	+·012	...	...	...	...	...	...	

It is necessary at this point to repeat the table of excess and deficiency of Nile floods during the period 1869 to 1905 which I gave in my previous communication, in order to show that the cyclical changes in latitude taking place in the southern belt made themselves felt as far north of the equator as the Upper Nile basin. Captain Lyons, from whose reports as Director of the Egyptian Survey Department I obtained my information, has gone very fully into the seasonal oscillations of the equatorial rain-belt, and the consequent rainfall over the Upper Nile basin. In the following table I have grouped into four series the ratios to an average flood during a period of 34 years, which have been computed by him for each year of the period, 1869 to 1905. And I have added the pressure anomaly which he has traced, by means of the Cairo barometric records, to be closely associated with the variations of the Nile floods.

I would remind you that the 1st and 3rd series, when floods were in

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excess, were found to correspond with remarkable exactness to those years when the southern belt was north of its mean cyclical position across South Africa, while the 2nd and 4th series contain the years when it was south of it; and that this correspondence was considered to indicate that the equatorial belt was shifting its latitude northwards and southwards with the southern belt. The pressure anomaly is taken from a paper communicated to the Royal Society by Captain Lyons "On the Relation between Variations of Atmospheric Pressure in North-East Africa and the Nile Flood."[1]

He has analysed in it the pressure variations of a number of stations in the African and Mediterranean areas, and by a comparison of the monthly pressure anomalies with the excess or deficiency of the flood, he has found that a remarkably close connection exists between the two in many cases, and especially in those of Beirut, Cairo, and Aden. The rainfall which affects the Nile flood occurs chiefly in the months of June to September, and by comparing the mean of the mean anomalies of these months with the floods he has found the rule to hold that − anomalies coincide with floods above the average, and + anomalies with floods below it. In Table I. the mean pressure anomalies which he worked out for Cairo for the years 1869 to 1903 have been inserted, and it is apparent that they are remarkably closely connected with the flood. There are only nine exceptions to the rule, and Captain Lyons examines each of them in relation to the pressure at Beirut, Alexandria, Aden, and Zanzibar, and concludes that only the two years 1883 and 1895 are in real disagreement. It is somewhat remarkable from the point of view of the present inquiry, that these exceptions occurred when the southern belt was at the extreme ends of its swing. It is also deserving of attention that no less than six out of the nine exceptions occurred round the years 1875 and 1893, when the southern belt, according to my theory, was nearest to the equator, both in consequence of its cyclical oscillation and its known seasonal migration in the months of June to September.

But pressure variations at the Mediterranean and African stations must be chiefly influenced by the neighbouring action-centres of the atmosphere; and if, as Hildebrandsson considers probable, there is an intimate relation between them all, the pressure in Egypt will vary according as the high-pressure systems are nearer to or farther away from that area. Captain Lyons has pointed out that in the Mediterranean area the pressure anomalies in summer are generally of the same character as those of Cairo and Beirut, but those of the Azores (Ponta Delgada) and Lisbon are usually inverse. Egypt and Abyssinia in their pressure anomalies in the summer months usually agree with the Indian or (+) type of pressure, but occasionally revert for a year or two to the opposite type.

It is a justifiable inference, then, that the high-pressure systems which affect North-East Africa will be farther north when the Nile floods are in excess, and nearer to Egypt when they are deficient. The Nile floods have been shown to be in excess when the southern belt was north of its mean position, and deficient when it was south of it; we therefore arrive at the first indication of importance regarding the oscillation of the high-pressure systems in the northern hemisphere. If our reasoning is correct

[1] *Proc. Roy. Soc.* A 76, 1905, p. 66.

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they must oscillate to and from the equator *in like phase* with the southern belt, moving south when that belt is going towards the pole, and north when it is receding from it.

With this clue we are now in a position to test the charts which I brought before the Society in 1898 in connection with the changes in the seasonal positions of the anticyclonic systems during the years 1881-1891. Though the scale is too small and the information regarding the exact position of the Atlantic system too scanty to justify any conclusion to be drawn from its movements in these years, the very southerly position of the Scandinavian system in 1884 and 1885 compared with 1890 and 1891, and the fact that the Atlantic system is found in 1885 in the most southerly position it occupied in any January, are evidences in favour of my conclusion. We have another means of testing the matter.

Evidences of an Oscillation afforded by the Tracks of Hurricanes.

In studying the oscillations of the southern belt I derived much information from an analysis of the hurricane-tracks near Mauritius, compiled by the Meteorological Council in 1891 for the period 1848-1885. They afforded strong grounds for thinking that such tracks are much influenced by the seasonal positions of the high-pressure system adjoining that area. I therefore turned to the records published in 1897, by Rev. J. Algué, Director of the Manila Observatory, in *Baguios ó Ciclones Filipinos*, by which he had been enabled to point out the places of origin, the paths and the zones of the hurricanes of the Far East, from June 1878 to 1897. The facts which he has given throw an interesting light upon the oscillations of the action-centres of the atmosphere, for he connects both the paths followed by the typhoons and their places of origin with the seasonal positions of the Siberian and Pacific high-pressure systems, as well as with the centres of low pressure in Hindustan and the Behring Sea.[1] He found that as the high pressure developed in Asia in the autumn, having migrated southwards after September, it pushed the hurricanes down into lower latitudes. Between 1879 and 1896 he traced 85 hurricanes which passed to the north of Manila, and 81 which passed to the south of it. The following table is arranged in such a way as to show how they were distributed between the several months, according to the groups he adopted to illustrate the connection between the seasons and the latitudes frequented by the hurricanes.

The following inferences may be drawn from Table II.:—

(1) The absence of all hurricanes to the north of Manila during the months of December to April indicates that they are pushed too far south in these months for Manila to feel them. Señor Algué records that the place of origin in the first group lies between lats. 5° and 12° N., which is a considerable distance to the south of Manila (lat. 14° 35′ N.). We find also from his observations that the barometric pressure of 757-759 mm. (29·803-29·882 ins.), which fosters the formation and favours the passage

[1] A translation of a lecture given by Dr. Paul Bergholz before the German Association in Munich, which appeared in the *Meteorologische Zeitschrift*, 1900, p. 71, will be found in the *Quart. Jour. Roy. Met. Soc.* **26**, 1900, pp. 165-168. The conclusions expressed are those of Rev. J. Algué.

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of hurricanes, is not recorded north of lat. 10° N. as a rule from December to April.

TABLE II.—Analysis of the Hurricanes which passed North and South of Manila Observatory, 1879-96.

	Year.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	Total.	
First Group	December																				North of Manila.
	January																				
	February																				
	March																				
Second Group	April																				
	May						1									1				2	
	October		1	3	1	1			1		1		1		2	1	1		2	15	
	November						1	1			1		1				1			5	
Third Group	June			1			1							1						3	
	July		1		1	1	3	1		2	2			4	1	2		1	1	20	
	August		1	2		1	1	2	1		1			1			1			11	
	September		2	1		2	1			5	1		2	1	3	5	4	2		29	
First Group	December			1			2		1					1	1	1	1			8	South of Manila.
	January												2			2	2			6	
	February																2			2	
	March																4			4	
Second Group	April				1	1		1	1				1				2			7	
	May			1		2								1		1	2			7	
	October				1	2			1		1		1				2			8	
	November			2	1	1	1			3		1		3	2	2	2	1		19	
Third Group	June							1		1					1		1	1	1	6	
	July			1						1	1			1			1			5	
	August						1								1				1	3	
	September			1		1				2	1			1						6	

(2) The monthly mean pressure at Manila in September is 757·1 mm. (29·807 ins.); in October 758·2 mm. (29·850 ins.); and in November 759·2 mm. (29·890 ins.). In November the "crossing line" is reached, and hurricanes pass more frequently to the south of Manila than to the north of it. It is noticeable that cases begin to be recorded in January 1890 after an interruption of more than 11 years, and that in the following years 1891-4 they reappear in December after an interval of 4 years. Then in 1894 the number of cases south of Manila, in the first group, reached the maximum during the period investigated. We may conclude, therefore, that the paths of the hurricanes were not being pushed so far southwards from 1890 onwards, and that in 1894 the Siberian system was abnormally far north during winter.

Hence we obtain from the tracks of the hurricanes in the Philippine Archipelago corroborative evidence that the northern belt of which the Siberian system forms a part was in the position we have assigned to it in 1894, viz. north of its mean latitude.

Señor Algué's report is, unfortunately, written in Spanish, but it contains a number of facts worthy of study which are suggestive of, and can be explained by, the existence of an oscillating belt. I have examined the daily isobaric charts of this region, prepared at Washington from the simultaneous International Observations taken during 1878-88, and have found that an oscillation of the Siberian high-pressure system to and from the equator is clearly indicated.[1]

[1] Just as this paper is leaving my hands comes a communication from Rev. J. Algué to

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Corroborative Evidence from the Barometric See-saw of the Lockyer Researches.

Both Hildebrandsson and Algué have found that India, situated between the Siberian and Australian high pressure systems, is influenced by both of them; but more especially by the Siberian. With the additional clue regarding the position of the latter system in 1893 and 1894, which has been obtained from the tracks of the typhoons in the Far East, we can approach Sir Norman and Dr. Lockyer's researches into the world-wide barometric see-saw, which they first observed to be taking place between India and Cordoba. The important part which the plateau of Iran plays in determining and modifying the weather in India during the cold season has long been established by the monsoon charts.[1] It is the plateau area of Persia and Baluchistan which is during the cold weather in the southern quadrant of the great anticyclone lying over Central Asia and Russia. We might expect, therefore, to be able to draw from Indian records information bearing upon the position of the northern belt in successive years. In the researches into the see-saw, curves have been plotted representing the barometric changes of short duration at Bombay, Madras, and Calcutta, and have been smoothed to eliminate the 4-year variations by the process already referred to. Dr. Lockyer states that the curve for Madras suggests maxima about 19 years apart, which in this respect conform with those of the curve for Sydney. The minima occur at 1874-5 and 1894-5 (again indicating the northerly position of the Siberian system in the latter years, and pointing to the possibility of a 19-year period in this respect also). Strong grounds also have been found by him for concluding that the Australian pressure variation is allied to, but is in part a modification of, the Indian variation, which would naturally be the case if the theory I have advanced for consideration is true. When the curves for Bombay and Madras are compared with those for Adelaide, Melbourne, Sydney, and Perth, the general resemblance is very striking, and in the recent publication by the Solar Physics Committee[2] Australia is definitely represented as being of the Indian or (+) type of pressure. Cordoba, on the other hand, is shown as being of the (−) type, and to be subject to barometric changes which are almost exactly *inverse* to those of the Indian area. And yet the researches prove that the Australian and Cordoba types are not inverse to one another, but differ by a time-phase of 6 years. But we have seen in the present inquiry that Dr. Lockyer's hypothetical curve for the South American area, which is largely influenced by the variations at Cordoba, supported the theory that the barometric pressure over this region, as

the Society, reporting that the year 1908 had been a remarkable one for typhoons in the vicinity of Manila. He specially alludes to one which passed to the north of the Observatory on November 20, between parallels 16° and 17° N., which he describes as an extraordinary track for such a late season of the year. Four years, therefore, before the belt will reach its most northerly position (1912) we find typhoons following a more northerly track than they do as a rule, just as in 1890, or four years before 1894, they were following a track in January which brought them far enough north to influence Manila for the first time on record. It is clear that the position of the northern belt, if my theory is correct, is all-important to these regions in the typhoon season.

[1] *India Weather Review*, 1893.

[2] *Monthly Mean Values of Barometric Pressure on 73 selected Stations over the Earth's Surface*, 1908. Compiled under the direction of Sir Norman Lockyer.

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well as over South Africa and Australia, was controlled and modified by the southern belt as it oscillated to and from the equator.

I suggest that the difficulty Sir Norman and Dr. Lockyer find in explaining this and similar discrepancies which they have recognised, and have repeatedly referred to, disappears when the latitudes of the places that are under consideration are taken into account, and their positions relative to the anticyclonic belts of the northern and southern hemispheres noted.

The Importance of Latitude in Analysing Barometric See-saws.

Bombay and Madras are at all seasons of the year far removed from and to the south of the parallel over which the central axis of the Siberian high-pressure system is found persisting. But they must be, and Blanford in 1879 showed that they were affected, by such an oscillation of that system as has been suggested. He pointed out that there existed a kind of long period see-saw of such a character, that while the pressure at the tropical stations of Indo-Malaysia was low that in Siberia was high, and *vice versâ*. The system being always on the north side of the Indo-Malaysian area, a see-saw must necessarily be detected if its effect on stations lying on each side of its central axis is compared. If variations of short duration are eliminated, pressure over a district will increase as the belt oscillates towards it and decrease as it moves away from it. And if the barometric variations of two places, such as Bombay and Cordoba, are compared, which are affected in an inverse manner by the adjoining high-pressure systems, the types will be inverse to one another. That the variations of the Australian stations which have been examined are of the same general type as those of India, is explicable on the assumption that both the Australian and Indian stations are on the south sides of their respective belts, which are oscillating in like phase.

The ratios of the Nile floods to a mean flood (Table I.) can be represented by a curve in the same manner as pressure variations. In Fig. 5 I have plotted them in a similar way to Figs. 2 and 4, which represent the pressure variations of Durban and Cape Town. The relation to the variations of the barometer at these South African stations is as striking as that of the pressure changes at stations lying within and outside a high-pressure system—such as those in Siberia and India, for instance. The changes in the ratios would be described as inverse to those of the barometer in South Africa, and Lyons has shown that they are also inverse to the pressure anomalies in North-East Africa. By adopting, then, the method of investigation followed in analysing the barometric see-saw we are led by the curve of the Nile floods to interpret the see-saw between India and Siberia as due to the oscillation of the northern belt, just as that between the Nile floods and pressure in South Africa may be interpreted by the oscillation of the southern belt. It has been suggested that the barometric see-saw is east-west rather than north-south. But besides Blanford's demonstration of the existence of a north-south see-saw in the Indian and Siberian areas, Hildebrandsson has shown a similar north-south see-saw between the Azores and Iceland, which Hann has endorsed from observations extending from 1846 to 1900. Lockyer's map divides the earth into

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two great pressure areas which lie for the most part east and west of one another, but within each there are numerous stations having doubtful or mixed types. Prof. Bigelow has found that there are many regions in which it was very difficult to say exactly which type was followed. It is noteworthy that Hildebrandsson has deduced from a study of pressure variations during the period 1874-84 (note the period he analysed) at a large number of places, mainly situated in the chief action centres of the atmosphere and widely distributed over the earth's surface, that there were several regions which exhibited opposite types of pressure variations. I have investigated a number of such cases, and have found that if the relative positions of the places with regard to the neighbouring high-pressure systems are taken into account, the reason for the types they present is not difficult to explain.

I have stated that if latitude is considered, it is possible to reconcile the apparent anomaly that, while the Indian variations of mean annual pressure from year to year are the inverse of those at Cordoba and similar to those of Australia, yet those of Cordoba and Australia are not the inverse of one another. If the curves of Madras and Bombay are carefully examined, it will be seen that they show a time-phase difference from those of Australia. India precedes Australia by two years. The Lockyer investigations have revealed that there is a time-phase difference between the maxima of Australia and South America of about six years, the Australian maxima preceding those of America (Cordoba) by that amount. India therefore precedes Cordoba by about eight years, according to the Lockyer researches. But by my hypothesis the belts in both the north and south hemispheres take 9·5 years to move from their most northerly to their most southerly positions, and a time-phase difference of "about 8 years" will mean that the two belts, swinging in like phase, are at alternate epochs respectively nearest to and farthest from stations lying between them and the equator, and on opposite sides of it. At that epoch when the northern belt is nearest to India the southern belt will be farthest from Cordoba, and when the southern belt is nearest to Cordoba the northern belt will be farthest from India.

In the fact that the Cordoba type is the inverse of the Indian, but is not inverse to the Australian, which is similar to the Indian, I find the strongest corroboration of the views regarding the oscillations of the two belts which I have endeavoured to bring before you. This paper is already too long, or a mass of corroborative details could be advanced in further support of the theory of oscillating belts. Should the theory be shown to be a fact, it will afford us a complete explanation why Russell found, as he did, that all the memorable droughts of history fitted in with his A and D series of New South Wales droughts. The drying up of lakes during certain epochs and their filling up again at others, as pointed out by Brückner over the world generally, by Russell over South America and Australia in sympathy with the 19-year cycle discovered by him, and quite recently by Lyons over Central Africa, will not excite surprise.

There remains the question of the agreement that has been pointed out in the Lockyer researches between the sunspot variations and the (+) and (−) barometric variations. We already recognise the fact that the seasonal migration of the high-pressure action-centres of the atmosphere synchronises with the sun's changes of declination. It is also easy to

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demonstrate from the daily charts of the North Atlantic, published by the Meteorological Council for the period, August 1, 1882, to September 3, 1883, that when the temperature of the surface water at noon was higher than that of the air resting upon it, anticyclones lost intensity or moved away altogether; whereas if it was lower, they increased in intensity if already there, or moved towards this area where such conditions prevailed.[1] It is certain, therefore, that if the belts of high pressure on each side of the equator, as represented by the anticyclonic action-centres of the atmosphere, have a cyclical oscillation such as suggested, this must be mitigated, retarded, or accelerated, according as the sun-spotted area changes.

To place many of the facts that have been collected before the Fellows would require the preparation of expensive isobaric charts, but enough has been said to encourage others to examine those which are available in the Society's library for themselves, and see the changes during successive years which have been taking place in the tracks of hurricanes and in the paths of anticyclones. They have encouraged me to bring the main facts forward, as the subject appears to be one well worthy of consideration.

DISCUSSION.

Commander M. W. C. Hepworth remarked that he believed he was right in saying that Col. Rawson accounted for the cycles of good and bad seasons, in the regions to which he referred, by the oscillations north and south only of the high-pressure belts. These belts existed as continuous belts only during winter months; in the Southern Hemisphere, for not more than four to five months; he could not say from memory for how many months in the Northern Hemisphere. Taking the South Atlantic, the monthly wind and pressure charts of that ocean, prepared in the Meteorological Office, and published by the Admiralty, showed the average oscillations of the South Atlantic anticyclone during the year to be from 5° to 6° north and south, but as much as 14° east and west. He recognised that these charts dealt with averages, but submitted that Col. Rawson's 19-years' cycles went a long way towards making up the period those averages covered. The positions north and south of the anticyclones of the great oceans had doubtless a great effect in determining the paths of depressions, travelling eastward across the adjacent land areas, which were responsible for a good deal of the weather experienced there. He thought, however, that the oscillations east and west would have as great, and perhaps a greater, effect on the conditions in those areas than the oscillations north and south. If the anticyclone of the South Atlantic, or that of the South Indian Ocean, extended well to the eastward it would cover a large portion of South Africa or Australia, as the case may be; and the same thing would occur in the case of South America, if the South Pacific anticyclone extended eastward, as it not infrequently did. He would ask Col. Rawson if he did not think this east and west movement of the permanent anticyclones would have a great effect upon the meteorological conditions of the regions to which he had made reference.

Dr. W. J. S. Lockyer said he wished to congratulate Col. Rawson on his paper. He himself had been busy with the southern belt, but he did not know how Col. Rawson had managed to find time to tackle both the southern

[1] Charts indicating this have been shown to Dr. Shaw by the author.

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and northern. Col. Rawson assumed that Russell was correct in saying the belt passing over Australia had an oscillation north and south, but having gone carefully through Russell's work, he found that if the means of several years were taken there would be no greater difference than 3° in latitude. Mr. Hunt also corroborated his view that this difference of 3° was within the error of determination of the latitudes. Unless the tracks of the anticyclones moved up and down, *i.e.* north and south, he thought they should not assume that there was an oscillation of the belt. He thought also that, regarding the question of this belt, he and Col. Rawson meant different things. Capt. Hepworth evidently agreed with Col. Rawson in assuming that in the Southern Hemisphere the high-pressure regions which during one season of the year were small, and during the other season were large and nearly united, were permanent systems. He, Dr. Lockyer, on the contrary believed these regions of high-pressure did not exist at all as separate systems. He thought they had a series of anticyclones travelling round the Southern Hemisphere from west to east, and that the different conditions of heat or cold changed the intensity of the anticyclones *en route*, accounting for their growth or the reverse. If they took the mean for several years, they were bound to find regions where the pressure was highest, and those would correspond to regions where the anticyclones were most intense. In discussing Russell's latitudes of these anticyclones, he could not find any oscillation of the belt other than 2° or 3°. If the year were divided into two sets of six months (the two seasons), he found that the belt of the anticyclones was narrower in some years than in others. He therefore concluded the belt did not change its position in latitude, but expanded and contracted cyclicly. In high-pressure years anticyclones were very large, and covered an extended belt both north and south. The mean position of this belt, however, did not move, only the fringes. They got the cyclic variation of weather and rain on these fringes, according to the sizes of the anticyclones.

Col. Rawson's way of coupling up the results of several workers was most interesting, and he hoped that when Col. Rawson had finished the Northern Hemisphere, he would go back again to the Southern. At the Solar Physics Observatory they had discovered a short-period pressure variation of about 4 years, India representing one type, and Cordoba the reverse type: they called it a short-period barometric see-saw. Australia and India went together, and were opposed to Cordoba. When all the short-period changes were eliminated, they obtained longer variations. One had expected to find the long-period variations for India and Australia alike, but such was not the case. Australia showed a 19-year variation, South America indicated also a 19-year change inverse in form to the Australian one, but the epochs of maxima and minima did not coincide. He thought that Col. Rawson in his paper had rather mixed up the 19-year and the 3·8-year variations.

Cordoba was in the south latitude, India in the north, with a great difference of longitude between them. There was an east and west pressure effect going on; if they analysed the pressures of the whole world as he had done they would find that the dividing line between these two regions of reverse pressures runs nearly east and west in the high northern and southern latitudes. On the equator it was nearly north and south. The see-saws were therefore more north and south in the high latitudes, and more east and west in the equatorial regions. He again congratulated Col. Rawson on his paper.

Dr. W. N. Shaw made some observations on the paper (which are referred to below).

Capt. D. Wilson-Barker said that the subject of anticyclones had always interested him, as he considered it was one of great importance. He was very glad to see both of Col. Rawson's papers, which had involved a great deal of

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work in their preparation. He did not quite agree with Col. Rawson that the belt went up and down. He thought that these anticyclones were all part of the great circulation they would some day discover. Such papers as those of Col. Rawson went towards elucidating these problems. There was very little doubt that these anticyclones formed the areas of feed for the cyclones. It would always be found that the polar side of all cyclones was only partly developed. The side next the anticyclones was that properly fed. He wished to thank Col. Rawson for his interesting paper.

The President remarked that what struck one most in the discussion was the want of periodical synoptic charts for a very large portion of the globe, which would help to decide whether the belt was swinging north and south, or east and west. These charts might also throw light upon some other meteorological problems. In many cases of abnormal weather they would like to know what area of the globe was affected. This winter, for instance, they had had an abnormal high-pressure in Iceland. They would be glad to discover what other regions had been affected by this.

Colonel H. E. Rawson, in reply, said that his paper formed only the framework, and he hoped many others would help to fill in the structure. Capt. Hepworth had referred to the east and west movement, but this was fully dealt with in his, Col. Rawson's, previous papers. He had acknowledged the influence of this movement, and he fully recognised its importance. The southern belt was of course not continuous all the year round, because of this seasonal east and west oscillation. The Australian system broke away from Australia, and moved to and from the east coast of South Africa, and he thought that in doing so it had a great effect upon the origin, path, and zone of the hurricanes in Mauritius. Dr. Lockyer was of a different opinion to himself about the permanent anticyclonic systems which compose the belts, but he had always been puzzled why Dr. Lockyer had rejected them and had accepted Russell's idea of nothing but travelling systems. How could he account for daily synchronous charts showing persistent systems complete with their prevailing winds in certain 10° squares of the North Atlantic, if there were nothing but a series of travelling anticyclones? If they examined charts of the ocean currents of the Southern Hemisphere they would find that winds were blowing for such a length of time over a distinct area that the normal ocean currents were modified and in some cases reversed. He was of opinion that the permanent systems squeezed out from themselves the travelling anticyclones, which went on to feed the adjoining system. Latitude must not be neglected when looking for evidences of the 19-year cycle.

With regard to what Dr. Shaw had said, he adopted Dr. Lockyer's hypothetical curve for Australia, because it had been arrived at independently, and confirmed in such a remarkable way the curve he had obtained for Durban; but Dr. Lockyer had not taken latitude into consideration, and it was open to question, according to his view, on this account. Dr. Shaw also asked the meaning of "India preceding Australia" in time-phase. This expression was adopted from the Lockyer researches, in which it had been pointed out that if curves of pressure variations were compared for a number of years, the maxima and minima of some large areas preceded or followed those of other areas by a fixed period of time.

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ON ERRORS OF ESTIMATION IN THERMOMETRIC OBSERVATIONS

By ALBERT WALTER, F.R.A.S., Royal Alfred Observatory, Mauritius.
Communicated by W. W. BRYANT, B.A., F.R.Met.Soc.

[Read May 19, 1909.]

IN examining the returns from a newly inaugurated series of second order meteorological stations in Mauritius, it was noticed in the early records, made by what may justifiably be termed "absolutely raw observing material," that a very large percentage of whole and half divisions occurred. It was thought that an estimate of the reliability of the observations could be arrived at by examining the frequency curve of the "tenths of estimation."

The progress of the observers was clearly indicated by the results; but notwithstanding long practice they all showed a decided tendency to record zeros and to accumulate certain other tenths. With a view to throwing some light on the anomalous results obtained, several series of decimal estimations by various trained observers were examined. The results appear to be of considerable interest, and of some importance in relation to the accuracy of measurement; they are collected in Table I. and shown graphically as percentage variations in the diagrams. There is evidently a break of continuity in the frequency curve between 9 and 0 and between 0 and 1, if the division crosses the mercurial column.

TABLE I.—FREQUENCY ON EACH TENTH (PERCENTAGE OF MEAN).

Curve.	Number of Observations.	Tenth.									
		0	1	2	3	4	5	6	7	8	9
1	58	60·3	...	...	...	...	39·7	...	...	...	...
2	165	65·4	0·0	2·5	0·6	4·3	21·2	0·6	3·0	3·0	0·0
3	731	27·5	4·9	9·3	8·5	4·0	16·0	4·5	3·3	13·6	8·5
4	322	13·0	7·5	3·4	26·4	13·4	5·3	7·8	13·7	7·5	2·2
5	177	53·9	4·3	17·9	45·3	0·0	12·8	0·0	7·7	9·4	0·0
6	184	33·7	6·5	15·2	1·6	3·8	11·4	2·2	2·7	16·9	6·0
7	4673	19·0	11·5	11·7	9·8	7·5	5·1	9·9	7·4	9·3	8·8
8	500	21·9	5·3	7·9	5·7	7·9	19·5	4·3	10·7	10·3	6·5
9	500	11·1	12·1	12·3	8·9	10·7	4·2	4·8	12·1	14·5	9·2
10	500	8·3	11·6	12·0	13·1	11·2	3·9	4·5	10·2	13·2	12·2
11	500	11·0	9·6	9·6	10·4	11·2	5·9	6·3	15·5	10·4	10·2
12	500	8·9	9·3	10·3	5·3	11·3	5·3	7·1	16·8	11·8	14·0
13	500	8·0	8·0	7·2	8·8	15·2	7·6	7·0	18·4	11·0	9·2
14	263	19·4	6·1	4·6	6·4	11·4	19·8	9·2	6·5	9·5	7·2
15	1595	12·5	8·9	10·3	7·2	13·0	9·3	14·2	6·6	10·3	8·2

Curves Nos. 1, 2, and 3 (Fig. 1.), which gave rise to the present investigation, are those of the observers at the new second order stations. No. 4 is the curve obtained from a record of thermometric observations made by an assistant with about 35 years' experience. The thermometer is one used in conjunction with a mercurial barometer, the temperature

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correction tables for which had been tabulated to the nearest whole degree Fahrenheit, interpolations being necessary for the corrections corresponding to fractions of a degree. The error of this thermometer was known by the observer, and a correction of $-0°{\cdot}3$ was applied before taking out the correction to reduce the barometer reading to 32°. The advantage

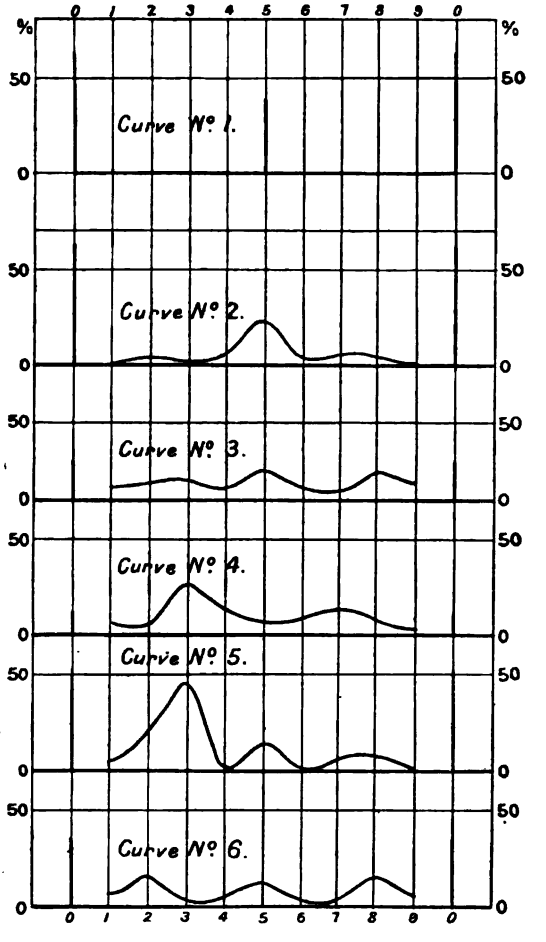


FIG. 1.

of a whole degree of temperature in using the tables is evident—at least it appears to have been so to the assistant in question. The manner in which the 3's control the frequency curve shows the importance of similar analyses where the fidelity of the observer is in question.

Another observer on the same thermometer obtained curve No. 5; he also knew the correction, and reduced the observations occasionally. His results show the same unfortunate tendency as the previous observer, as well as a high percentage of zeros, due probably to the fact that all his observations were not reduced.

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A third observer, to whom the error of the thermometer was unknown, obtained Curve No. 6.

The investigation was next carried to the *Greenwich Observations* for the years 1903 and 1904; and the results tabulated for the thermometers exposed in the Stevenson screen—they are shown in curve No. 7 (Fig. 2). In addition to the usual predominance of zeros the Greenwich observers

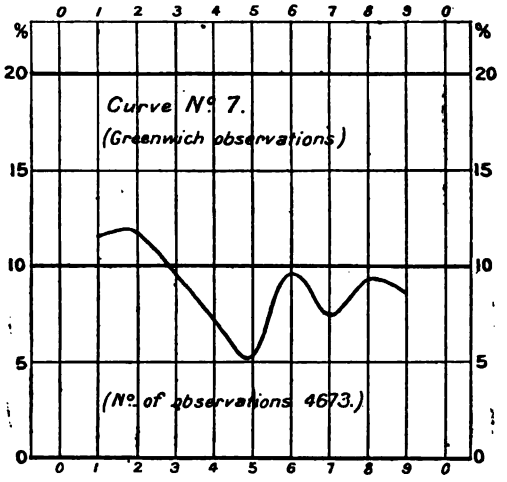


FIG. 2.

appear to have a decided objection to the half division, which is shared by the best trained observers at Mauritius. In tabulating these results the corrections which had been applied to the thermometer readings were very clearly indicated in each case; for instance, thermometer No. 37467 N. and Z. had a correction of $-0°{\cdot}5$, and the distribution was accordingly as follows (vol. of *Greenwich Observations*, 1903):—

Tenth.	Frequency.	Tenth.	Frequency.
0	30	5	65
1	40	6	18
2	31	7	36
3	40	8	40
4	43	9	22

This fact may occasionally be of use in dealing with the reduction of old observations—if the thermometers have been graduated in the usual way by carrying the divisions across the column of mercury—when there is any doubt as to whether a correction (or what correction) has been applied.

It is certain that these irregularities are not accidental. The theoretical frequency curve should evidently be a straight line, and if we

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apply Prof. Pearson's criterion of fit[1] we obtain a value of $\chi = 14{\cdot}37$; a value which precludes all possibility of an accidental origin for such a system of deviations, if the normal curve represents the true frequency distribution.

We are fully justified, therefore, in seeking for a definite cause for these irregularities.

From *a priori* considerations we should expect, in all eye estimations, to find that the space between ·05 and ·15 should be allotted to ·1, between ·15 and ·25 to ·2, etc. But it should be remarked that ·5 is a point almost as well defined on the stem as if it were actually ruled, and, moreover, the fact that it is not ruled gives this division the characteristic of a mathematical point. Absolute or nearly absolute coincidence is, in consequence, the necessary condition for the registration of ·5. In other words, the frequency of the 5s is spread over only a very small portion of the stem, as compared with that of the other divisions; hence the small number of 5s recorded. From the Greenwich observations it would appear that the portion of the stem allotted to the 5s extends from about 4·75 to 5·25, or, on the average, one-half of that given to the other divisions.

Another factor which possibly controls the estimations in the case of certain thermometric observations is the error arising from the over-estimation of an all white interval as compared with an all black interval; the former is generally overestimated, as will be seen at once from Fig 3, and this apparently is the reason for the general decrease from the 1s to the 9s.

The most difficult estimation is that of ·7 or ·3, and the author has generally found that personalities in decimal estimation centre round these two divisions. The average observer avoids the sevens; occasionally,

[1] *Philosophical Magazine*, vol. **50**, No. 302.

$$P = e^{-\frac{1}{2}\chi^2}\left(1+\frac{\chi^2}{2}+\frac{\chi^4}{2\cdot4}+\frac{\chi^6}{2\cdot4\cdot6}\right) \text{ (when the number of groups is odd);}$$

where $\chi = \sqrt{\frac{\overline{v^2}}{m}}$.

v = the deviation of the observed frequency (m^1) from the theoretical frequency (m).

Group.	Observed Frequency m^1.	Deviation v.	v^2.	v^2/m.
1	537	+70	4900	10·49
2	547	+80	6400	13·70
3	458	−9	81	0·17
4	350	−117	13689	29·31
5	238	−229	52441	112·21
6	462	−5	25	0·05
7	346	−121	14641	31·35
8	434	−33	1089	2·33
9	411	−56	3136	6·72
Sum	...	...	...	206·41 $= \chi^2$.

Theoretical frequency = 467 on each tenth.

The frequency for 0 is omitted, as there is evidently a break of continuity in the curve at this point.

$$\log P = \overline{38}{\cdot}45705.$$

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however, observers are found with a decided tendency to record them, which is especially marked when the observer has recognised an inherent objection to these divisions and has endeavoured to correct it.

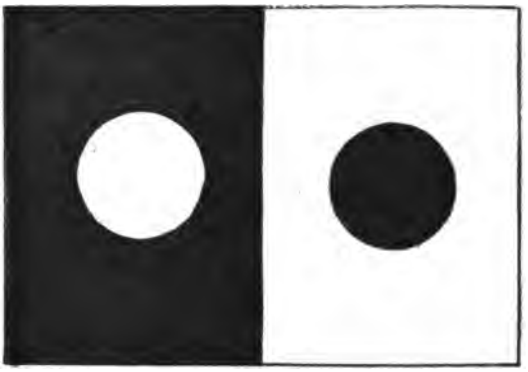


FIG. 3.

We see, therefore, that in this, the most simple of all observations, the law of errors, as usually enunciated, does not hold: a result which emphasises still further Prof. Pearson's warning concerning the invalidity of the application of the normal probability curve to many error-frequency distributions. In practice, results which follow the normal frequency curve appear to be the exception, not the rule.

The excess of zeros can be eliminated to a certain extent by graduating the stems in such a way that the dividing lines do not cross the mercurial column. This will also obviate errors due to the overestimation of an all white interval as compared with an all black.

In order to ascertain whether the size of the scale division influenced in any way the accuracy of the estimation, six thermometers were graduated with scales, the divisions of which increased by 0·4 mm. [·016 in.] from 0·8 mm. [·032 in.] to 2·8 mm. [·110 in.], the scales being ruled on paper and pasted on to the stem; so that the conditions stipulated above were fulfilled. The results are shown in curves Nos. 8 to 13 (Fig. 4). Some of the irregularities in these curves are certainly due to the small number of observations—averaging 50 on each division—but there are several points of considerable interest. We notice first the entire absence of any tendency to decrease from the 1s to the 9s. Curve No. 8 shows the marked characteristics of an untrained observer (excess of 0s and 5s), the divisions being altogether too small for decimal estimation. In all the others we notice a marked decrease in the 5s, and in curves Nos. 11, 12, and 13 the observer's personality on the 7s is very prominent. Curve No. 10 appears to be the one most in accordance with what might be expected from *a priori* considerations, and it is probable that the true error distribution for decimal estimation, if the dividing lines are sufficiently fine, will be found to be characterised by a double hump with minima at 0 and 5.

The extraordinary methods adopted by some makers in the construction of thermometer scales seem to call for remark here. One

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thermometer by a well-known maker, forwarded to Mauritius through the National Physical Laboratory in December 1903, was divided into half degrees, the dividing lines occupying 0·245 (nearly $\frac{1}{4}$) the space between

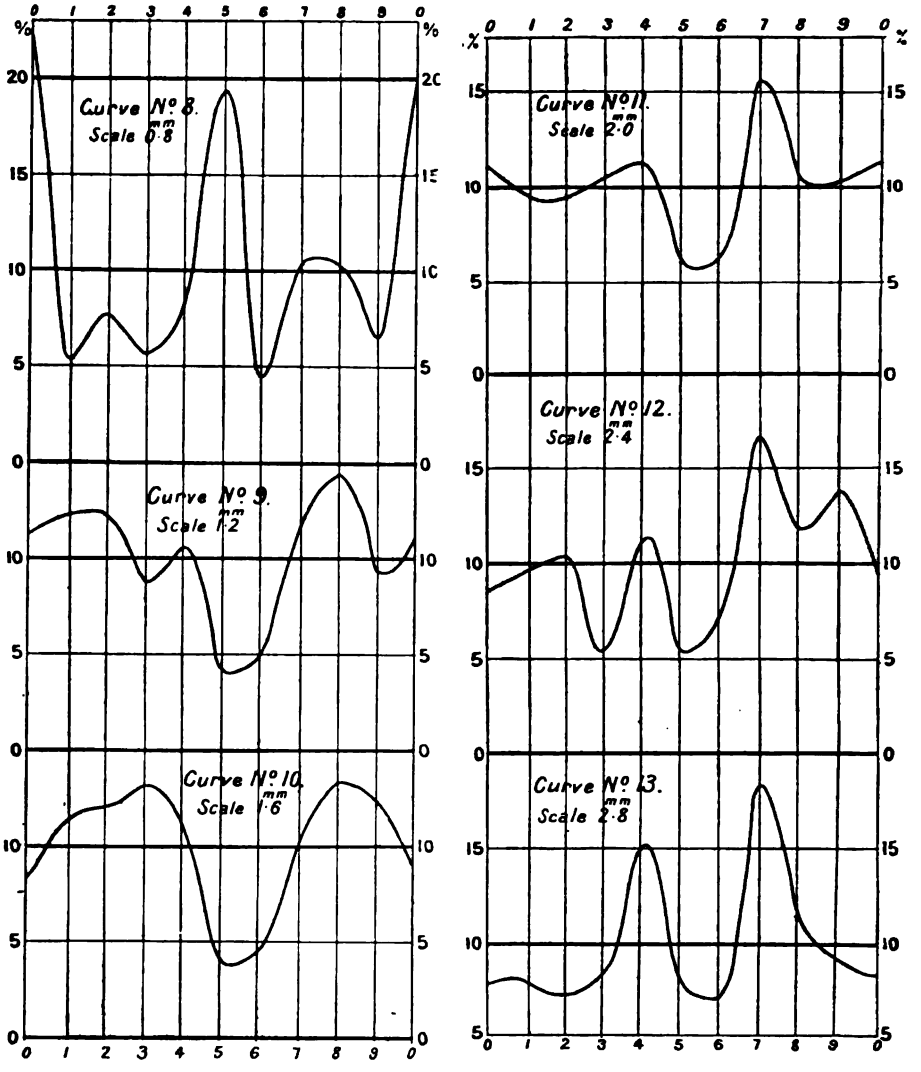


FIG. 4.

the edges of two consecutive divisions. The thermometer was specified in the requisition as a thermometer "to be used with the Kew Unifilar for deflection observations," and it is difficult to assign a reason for the half division. The frequency curve, No. 14 (Fig. 5), shows how it has affected the accuracy of the results.

Two Symons's earth thermometers for use at a depth of 10 feet are even more astonishingly divided: each degree, which is 1·72 mm. [·068 in.]

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in width, being subdivided by fine lines into 0°·2 Fahr.; each division is therefore 0·34 mm. [·013 in.] wide. The observer is supposed by this means to be able to read to 0°·05. In reality, as will be seen from curve

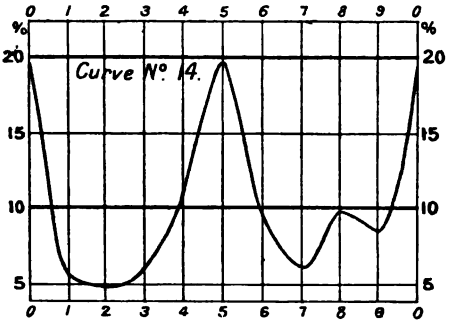


FIG. 5.

No. 15 (Fig. 6), which gives the frequency of the *tenths* of degrees, the temperature is, more frequently, only read to the nearest 0°·2: a result which might have been expected, it being practically impossible for the unaided eye to subdivide divisions equal to 0·34 mm. [·013 in.].

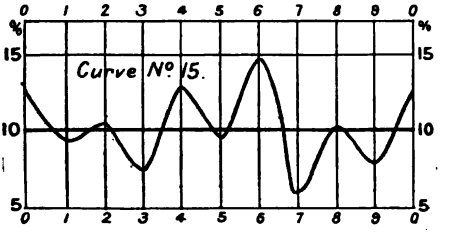


FIG. 6.

For ordinary meteorological purposes the errors due to estimation into tenths of a degree, on a rationally divided thermometer, are insignificant; but it frequently happens that the determination of the errors of thermometers by comparison in a water-bath are seriously influenced, when the corrections to the nearest 0°·1 are required, if the thermometer is recording a temperature in the vicinity of a whole degree at the time of observation.

At Mauritius, thermometers are compared in water in a double lead-lined cistern. The increase of temperature in this bath is very slight even when the temperature of the air is rising rapidly; it frequently remains absolutely constant for a period of 20 or 30 minutes, and hence great care has to be exercised. The comparisons are invariably made by the Chief Assistant, and it is the practice to record the temperature to 0°·05 Fahr.; that is to say, if the thermometer appears to record slightly over 0°·5 it would be entered as 0°·55. The care exercised in avoiding parallax, the use of a magnifying glass, the constancy of the bath, and the time occupied over each reading, together with the fact that four readings are required to form a complete comparison—readings being

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made from left to right, and back from right to left, twice, the water being stirred between the two series—give a signification to such readings. A complete comparison consists of three sets of four readings, and more if the results are inconsistent. Notwithstanding that the readings are made with the thermometer turned so as to observe the column of mercury clear of the divisions, which do not extend right across the stem, there is distinct evidence, in the case of the two Kew Thermograph Standards, that the errors are less by about 0°·05 Fahr. when both thermometers are recording near or on a division than when they are recording between them.

In certain special investigations, such, for instance, as the determination of temperature within the glass shades covering the Kew Magnetograph when temperatures are required to 0°·01, thermometers constructed with enlargements in the capillary tubes, increasing the scale-value so that 0°·1 becomes about 1·5 mm. [·059 in.], can be used with advantage. Such thermometers are in use at Mauritius for this purpose, and with a view to determining what effect the considerably increased scale-value had on the sensibility of the thermometer, the coefficient of sensitiveness was determined in the manner described in a paper communicated by the author to the South African Philosophical Society, with the results given in Table II., which will be seen to compare very favourably with those obtained from thermometers of ordinary construction.

TABLE II.

Thermometer. (0°·1 = 1·5 mm.)	Coefficient of Sensitiveness.	Thermometer. (1°·0 = 1·5 mm.)	Coefficient of Sensitiveness.
N. & Z. 120564	0·276	M. O. 1348	0·182
,, 120565	0·363	,, 1349	0·278
Hicks 216449	0·322	,, 1350	0·220
,, 216450	0·349	,, 1351	0·176

DISCUSSION.

Mr. W. W. BRYANT said the subject interested him very much, since decimal equation entered into astronomical observations and other matters quite apart from the reading of the thermometers. Certainly there was a great tendency to have an enormous number of 0s. He was quite in agreement with the writer's deductions, though people who ignored differences of less than half a degree or so might consider the paper superfluous. As regards the graduation of thermometers, he thought a hint to the makers might have some effect.

Mr. W. MARRIOTT said that from a cursory examination of 92 returns sent into the Society for the last month it was found that 62 observers read their thermometers to tenths of a degree indiscriminately; that 6 read to two-tenths of a degree; that 18 read to halves and quarters; that 3 read to whole degrees and halves; and that only 3 observers read to whole degrees. These figures he thought tended to show that the observations sent to the Society were carefully taken. The maximum and minimum thermometers were read in a horizontal position, while the dry- and wet-bulb thermometers were upright; this might possibly make a difference in the readings. He had always recommended observers to read their thermometers to tenths of a degree. This was very

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important in the case of the dry- and wet-bulb thermometers, especially when the temperature was low, as then small differences between them had a great effect on the humidity deductions. He thought that all the thermometers should be read to tenths of a degree, otherwise it would be useless to have the thermometers verified at the Kew Observatory.

Mr. R. G. K. LEMPFERT, adverting to Mr. Marriott's remarks, said that he advocated reading the thermometers to whole degrees at stations where only maximum and minimum temperatures are observed. If the reading be taken to the nearest whole degree the mean temperature for the month is not appreciably affected by omitting the decimals of a degree. A difference of half a degree in the extreme temperatures for a given day is also a matter of no importance. On the other hand, the omission of the decimals lightens the labour of the observer and of the computer who has to deal with the observations subsequently. When dealing with a large body of statistics the saving to the computer may be considerable. In the case of dry- and wet-bulb observations there could be no question of the desirability of reading to a tenth of a degree.

Mr. R. INWARDS said that he thought it would be simple to make a tube with a micrometer eye-piece to read to tenths with absolute accuracy.

Mr. J. HOPKINSON, who had to leave the Meeting before the discussion on this paper, wrote that his test of the accuracy of estimations in reading thermometer scales to the tenth of a degree had been nearness of the approach of the mean of a large number of readings to $4\frac{1}{2}$; thus while in a month of 30 days there might be considerable deviation from 135, in a year of 365 days the sum of the tenths should be somewhere near 1640 or 1645. He admitted that the frequency-curve of the tenths was a much better test, and he had now applied this to his own observations. He had taken out the tenths of dry- and wet-bulb and maximum and minimum readings for 500 days near the commencement of his observations and for 500 days about 20 years later, but having in the earlier period inked in the figures in his note-book he could not be certain which were his own original entries, while in the later period he had been able to avoid taking in all readings not made by himself. In the earlier period there seemed to be a greater preponderance of 0 readings during the time that he was usually away from home, doubtless due to the readings being taken by one of his servants, but he could not trace any other difference in the estimation of the tenths. The results are given in the following table, each of the first four lines giving the readings of 2000 observations, and the last line giving the readings of 4000, that is for the four thermometers for 1000 days:—

	0°	·1°	·2°	·3°	·4°	·5°	·6°	·7°	·8°	·9°
Earlier period . . .	18·5	8·3	11·8	10·9	7·6	8·3	8·1	8·0	11·1	8·4
Later period . . .	13·3	10·5	10·9	11·6	8·2	8·7	8·1	9·2	10·4	8·1
Dry- and wet-bulb . .	17·3	8·9	11·3	11·3	7·3	8·2	7·3	7·8	10·7	8·3
Maximum and minimum .	14·5	10·0	11·4	11·2	8·5	8·8	8·8	9·5	10·8	8·2
Mean (4000 obs.). . .	15·9	9·4	11·3	11·2	7·9	8·5	8·1	8·6	10·8	8·3

The later period is seen to come out distinctly better than the earlier in the 0 division not being so much overestimated, and there is a slight improvement in most of the other divisions except in the overestimation of ·3° and the underestimation of ·9°, and it appears to be easier to read correctly the maximum and minimum thermometers than the dry- and wet-bulb, probably from parallax, it being more natural in reading to move the head to right or left than up or down.

Corrections for the index errors of the thermometers are not made in the original entries, being applied only to the monthly means.

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Death through Lightning, and Workmen's Insurance.

The question whether a workman killed by a stroke of lightning while at work can be regarded as having met his death owing to an accident during the course of his employment has engaged the attention of the Court of Arbitration for Swabia and Neuburg. It appears that on July 13, 1898, while engaged in plastering the passage inside a new dwelling a workman was killed by a flash of lightning, which struck the fireplace and passed through the house. The father of the workman applied to the Bavarian Builders' Friendly Society for payment of the funeral benefit, but this was refused on the ground that the requisite connection between the death and the work was lacking. The Union based its refusal on the consideration that it is necessary to prove not only that the accident occurred at the place of work, but also that it was produced by the work, that is, that it was occasioned by a danger standing in close relation to the work. Against this decision the father appealed to the Court of Arbitration, which ordered the friendly society to pay to the applicant funeral benefit to the amount of £4 : 13s. and the incidental costs. The Court held that in any circumstances bodily injury caused to an insured person by lightning while following employment must be recognised as an accident at work, irrespective of whether the lightning stroke occurs in the open or in a protected room, or whether the conditions determining the direction of the path of the lightning can or can no longer be recognised.—*Electrical Review*, August 6, 1909.

Electricity of Rain.

In a paper on the "Electricity of Rain and its Origin in Thunderstorms" read before the Royal Society on June 4, 1909, Dr. G. C. Simpson stated that during 1907-8, an investigation was undertaken at the Meteorological Office of the Government of India, Simla, into the electrical phenomena which accompanied thunderstorms. After describing the lines of research adopted and the results obtained, Dr. Simpson puts forward the following theory for the origin of the electricity of thunderstorms :—

It is exceedingly probable that in all thunderstorms ascending currents greater than 8 metres [26 ft.] a second occur. Such currents are the source of large amounts of water which cannot fall through the ascending air. Hence, at the top of the current, where the vertical velocity is reduced on account of the lateral motion of the air, there will be an accumulation of water. This water will be in the form of drops which are continually going through the process of growing from small drops into drops large enough to be broken. Every time a drop breaks, a separation of electricity takes place, the water receives a positive charge, and the air a corresponding amount of negative ions. The air carries away the negative ions, but leaves the positively charged water behind. A given mass of water may be broken up many times before it falls, and, in consequence, may obtain a high positive charge. When this water finally reaches the ground, it is recognised as positively charged rain. The ions which travel along with the air are rapidly absorbed by the cloud particles, and in time the cloud itself may become highly charged with negative electricity. Now within a highly electrified cloud there must be rapid combination of the water drops, and from it considerable rain will fall : this rain will be negatively charged.

A rough quantitative analysis shows that the order of magnitude of the electrical separation which accompanies the breaking of a drop is sufficient to account for the electrical effects observed in the most violent thunderstorms. All the results of the observations of the electricity of rain described in the paper are capable of explanation by the theory, which also agrees well with the actual meteorological phenomena observed during thunderstorms.

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THE INTERDIURNAL VARIABILITY OF TEMPERATURE IN ANTARCTIC AND SUB-ANTARCTIC REGIONS.

By R. C. MOSSMAN, F.R.S.E., F.R.Met.Soc.

[Read June 16, 1909.]

In a region like the Antarctic, where the prevailing temperature and pressure distribution, wind circulation, and general topography are but imperfectly understood, it is not possible to discuss any meteorological question with that confidence which we associate with a substantial backing of observational data. Although the past decade has witnessed a great effort by international co-operation to roll back the veil of mystery which until recent years enshrouded this region, yet the unexplored areas absolutely unrepresented by any data are so large, and the distances separating the sphere of work of the various expeditions are so great, that at best we can only obtain a glimpse here and there of the climatic features of the region south of lat. 60° S.

The present inquiry deals with the variability of temperature, or day to day difference in the mean temperature of successive days, at a few places for which the necessary detailed daily observations are available. There still remain for discussion the results of the German, French, and Swedish expeditions, the detailed reports of which have not yet appeared. Further data of an important character will also be furnished by Charcot's expedition now in the field, and also from Mr. Shackleton's expedition.

In the following discussion of the results I have adopted a very general treatment of the data, because any conclusions that are arrived at outside of the established fundamental factors governing the variability of temperature are necessarily of a highly tentative nature. This paper, however, may not improbably help to throw light on special points connected with Antarctic climatology which might otherwise be overlooked.

Position of Stations and Sources of Information.

The following are the stations for which the temperature variability was computed. The data refer to either one or two years.

Discovery.—The British Antarctic Expedition spent two years (February 9, 1902, to January 31, 1904) at Ross Island, lat. 78° 49′ S., long. 166° 20′ E. The station lay close to the west coast of a great bay, while the westerly coast-line ran northward from the station for about 9° of latitude. The temperature variability has been computed from daily means based on observations taken every two hours, the daily temperatures being given in "National Antarctic Expedition," 1901-1904, *Meteorology*, Part I. pp. 374-384.

Cape Adair—The *Southern Cross* Expedition, organised at the expense of Sir George Newnes, Bart., M.P., was under the leadership of Mr. C. E. Borchgrevink. The station was located at Cape Adair (lat. 71° 18′ S., long. 170° 9′ 30″ E.), and here observations were taken from March 3, 1899, to January 29, 1900. Cape Adair is the extremity of a peninsula about 20 miles long, forming the north-eastern shore of a large bay

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called Robertson Bay. The station was situated on a bank of pebbles facing the open sea to the north and west, and Robertson Bay on the south and south-west. A range of mountains averaging 3000 feet in height lay behind to the east and south-east, the base of the mountains being 1000 yards from the thermometer screen. Observations were made at intervals of two hours between the hours of 9 A.M. and 11 P.M., but from June 13 to July 31 every two hours night and day. The temperature variability has been computed from the mean of the 9 A.M. and 9 P.M. readings, the following being the values thus obtained from March 1899 to January 1900:—

March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Jan.
2°·3	4°·6	6°·3	7°·7	8°·9	9°·4	6°·4	5°·1	4°·2	2°·0	2°·3

During the 44 days June 18 to July 31, during which period the temperature was taken at two-hourly intervals, the mean variability was 7°·6, calculated from daily means deduced from 12 readings, and 8°·4 from the mean of 9 A.M. and 9 P.M., consequently the above values give too high a mean for strict comparison with the values from the other stations which are derived from mean temperatures based on a large number of daily observations. For the winter season (June, July, and August) the values given in Table I. have been reduced by 0°·8 in conformity with the above comparison, and a smaller correction applied to the other months. The correction applied was − 0°·6 for May and September, − 0°·5 for April and October, − 0°·4 for November, and − 0°·2 for the summer months including March; the means for February are interpolated. In the further analysis of the data the values refer to temperature means deduced from the 9 A.M. and 9 P.M. observations. The temperature data are given *in extenso* in *Magnetical and Meteorological Observations made by the "Southern Cross" Antarctic Expedition 1898-1900*, pp. 64-85.

Belgica.—The observations during the *Belgica* Expedition were made in the pack where the ship was frozen in for over a year. The longitude varied from 80½° to 97° W., but the latitude only between 69½° and 71½° S. The period described is from March 1898 to February 1899, and detailed hourly values are given in M. Arctowski's report, *Expedition Antarctique Belge*: "Météorologie: Rapport sur les observations météorologiques horaires."

South Orkneys.—This was the winter station of the Scottish National Antarctic Expedition in 1903. This group consists of two large islands and a number of small ones. The observing station at Scotia Bay is in lat. 60° 44′ S., long. 44° 39′ W., and is situated on a narrow beach separating two bays. Mountains from 1000 to 2000 feet lie to the west of the station. Detailed hourly observations are given in *Scientific Results of the Scotia*, vol. ii. pp. 111-127, and in *Anales de la Oficina Meteorologica Argentina*, vol. xvi. pp. 36-47. The period discussed is the two years ending March 31, 1905; the values for the first three months of 1905 being taken, by permission of Mr. W. G. Davis, from the MS. observations, now in course of publication by the Argentine Meteorological Office.

South Georgia.—This is a large island some 22° of longitude east of the Falkland Islands. The data refer to two stations—viz. that occupied by the German Expedition of 1882-83 at Molke Haven, lat. 54° 31′ S., long. 36° W., on the north side of the island, and another station on the

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south side of the island at Grytviken, in lat. 54° 14′ S., long. 36° 33′ W., for which hourly values are available since July 1907. The data discussed are therefore for two years, 1882-83 and 1907-8; the values for the former year being taken from *Die internationale Polarforschung*, 1882-83, *Die Beobachtungsergebnisse der deutschen Stationen*, Band ii.: sud-Georgien, and for 1907-8 from the MS. sheets by permission of Mr. W. G. Davis.

Falkland Islands.—The observations refer to Cape Pembroke for the years 1903 and 1904. The daily means were computed from four-hourly observations given *in extenso* in pp. 218 to 243 of the *Scientific Results of the "Scotia,"* vol. ii. The position of this station is lat. 50° 41′, long. 57° 43′ W.

Orange Bay and *Ushuaia.*—The data for *Orange Bay* and *Ushuaia* refer to means deduced from hourly observations at the former and tri-daily observations at the latter station. The data appear in *Mission Scientifique du Cap Horn*, 1882-83, tome ii. "Météorologie," the Orange Bay values being given in pp. 26 to 47, and the Ushuaia means in pp. 90 to 134. The period covered by the Orange Bay observations is from October 1882 to August 1883, the means for September being interpolated to complete the year. For Ushuaia the data refer to the year ending November 1883. Orange Bay is in 55° 31′ S. lat., 68° 05′ W. long., and Ushuaia in lat. 54° 52′, long. 68° 07′ W. Orange Bay is open to the east, and there are high mountains close to both stations.

New Year's Island.—This is a small island close to Staten Island, in lat. 54° 39′, long. 64° 07′ W. The data refer to one year, viz., that of 1905, and the mean temperature was deduced from seven observations daily, taken at 7, 8, and 10 A.M., and 1, 4, 7, and 10 P.M; these observations are in MS.

Factors affecting the Variability of Temperature.

The variability of temperature, as is well known, is least in oceanic, and greatest in continental localities. Where there is much moisture the day to day changes are small, but in continental regions where there is little water-vapour, great temperature changes take place. An important factor in this connection is the position which the station occupies with reference to the track of cyclones, because the greater the frequency of wind-variation the larger will be the variability. This cyclonic effect is at a winter maximum at such places as the South Orkneys, which for some six months of the year are on the edge of a continent, owing to the freezing up of the Antarctic Ocean, while, at the same time, strictly oceanic conditions prevail at no great distance to the north of the station. At the South Orkneys we have a very great difference in the mean temperature of the winds. For the seven months, April to October 1903, the south wind had a mean temperature of only 5°·2, while the north-west was as high as 26°·9, a difference of 21°·7. At Cape Pembroke, Falkland Islands, there was only a difference of 7°·0 between the warmest and coldest wind during the same period. It is therefore easy to understand why the variability of temperature should be so much greater at the southern station, as the South Orkneys further appear to lie in or near to the central track of the rapidly moving cyclonic systems, which, after passing south of Cape Horn, frequently strike south-east into the

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Weddell Sea, a little to the west of the South Orkney group.[1] The Falkland Islands, on the other hand, lie well to the north of the normal cyclonic track, and here the changes in wind direction were not nearly so sharp as at the southern station, where, as we have seen, the temperature contrast between a sea and what is essentially a land wind are so marked, owing to the sea being frozen to the south. At the winter quarters of the *Discovery* the variability was considerably less in winter and greater in summer than at the South Orkneys. In other words, the contrast between a sea and a land wind was less in winter and greater in summer than at the South Orkneys. Cape Adair, some 460 miles to the north of Ross Island, where the *Discovery* was frozen in for two years, was much under the influence of the sea, and here, as at the South Orkneys, there was a great difference in the temperature of sea and land winds—a feature, however, being the high temperature associated with winds from the east-south-east, which partook of the nature of a Föhn. At Cape Adair the variability was apparently greater than at Ross Island, but as the observations only extend over eleven months, and refer to a different period from the *Discovery's* records, one cannot dogmatise on this matter. At the winter quarters of the *Belgica* conditions of sea and ice distribution seem to be much the same as at the South Orkneys, although the latter station is nearly 10 degrees of latitude to the north of the *Belgica's* position. This is supported by the large difference on the *Belgica* in the mean temperature of the wind during the winter season, the south-west wind having a mean temperature of $-9°{\cdot}9$, and the north-east (in which direction the open sea was nearest) a mean of $12°{\cdot}6$, a difference of $22°{\cdot}5$. As the lowest mean of all $-12°{\cdot}1$ was recorded during calms, the greatest temperature change would occur at this season, when a calm was succeeded by a wind from the north-east. As pointed out by Dr. Shaw,[2] the lowest temperatures in the Antarctic "are likely to be found in stagnant air, and any wind that disturbs stagnant air will be a warm wind." With regard to places in the Cape Horn region and in the ocean to the east, the temperature variability is greatly reduced, because conditions are in the main insular. To this there are some slight exceptions. At Ushuaia in Tierra del Fuego, owing to the presence of high mountains and the station being at some distance from the open ocean, conditions are somewhat continental during the winter, while at South Georgia the relatively frequent occurrence of Föhn, and the comparative proximity of pack-ice to the east and south, are factors which increase the temperature variability at this station. These influences are not present at such strictly insular situations as the Falkland Islands, New Year's Island, and Orange Bay, where a small and steady temperature variability prevails at all seasons of the year, these stations being also in the Westerly wind system, where great variations in wind direction are somewhat infrequent.

General Summary of the Results.

The monthly, annual, and seasonal values of temperature variability are given in Table I. With regard to the seasons, *Spring* includes

[1] *National Antarctic Expedition*, 1901-1904, "Meteorology," Part I. p. 447.
[2] *Ibid.* p. x.

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TABLE I.—VARIABILITY OF TEMPERATURE.

STATION.	Lat. S.	Long.	Period. Years.	Year specified.[1]	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Spring.	Summer.	Autumn.	Winter.
	° ′	° ′			°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Discovery, Ross Island	78 49	166 20 E	2	1902 – 1904	2·0	2·8	4·2	4·4	6·1	5·8	6·4	6·4	5·7	4·1	3·4	2·7	4·5	4·4	2·5	4·9	6·2
Cape Adair . .	71 18	170 9 E	1	1899 – 1900	2·1	(2·1)	2·1	4·1	5·7	6·9	8·1	8·6	5·8	4·6	3·8	1·8	4·6	4·7	2·0	4·0	7·9
Belgica . .	70 35	87 22 W	1	1898 – 1899	1·4	2·2	4·9	8·5	7·4	9·7	8·3	9·5	8·5	4·3	3·8	2·2	5·9	5·5	1·9	6·9	9·2
S. Orkneys . .	60 44	44 39 W	2	1903 – 1905	1·5	1·5	2·4	5·4	8·4	9·9	8·5	9·0	7·3	5·8	2·2	1·2	5·3	5·1	1·4	5·4	9·1
S. Georgia . .	54 31	36 00 W	2	1882 – 1883	2·9	3·9	3·8	3·4	4·0	3·3	4·1	5·1	5·0	3·2	3·0	2·4	3·7	3·5	3·1	3·7	4·2
	54 13	36 33 W		1907 – 1908																	
Cape Pembroke . .	51 41	57 43 W	2	1903 – 1904	2·0	2·4	2·3	2·4	2·1	2·2	2·3	1·9	1·8	1·8	1·7	2·0	2·1	1·8	2·1	2·3	2·1
Orange Bay . .	55 31	68 05 W	1	1882 – 1883	3·1	3·0	3·0	2·2	2·6	3·0	2·4	3·7	(2·9)	2·8	2·7	4·4	3·0	2·8	3·5	2·6	3·0
Ushuaia . .	54 52	68 07 W	1	1882 – 1883	4·4	3·5	3·5	2·5	3·3	2·6	2·2	6·1	3·1	3·3	3·8	2·6	3·4	3·4	3·5	3·1	3·6
New Year's Island .	54 39	64 07 W	1	1905	1·6	2·3	2·2	2·2	2·3	2·6	2·8	2·7	2·9	2·5	2·1	1·8	2·3	2·5	1·9	2·2	2·7

[1] For exact periods covered by the observations see description of positions of the stations given in pages 259 to 261.

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September, October, and November; *Summer*, December, January, and February; *Autumn*, March, April, and May; and *Winter*, June, July, and August. This distribution of seasons is not quite in accordance with what is actually the case in high latitudes, where a different grouping of months would have better represented the seasons, but as data from comparatively low latitudes are also under discussion, it was necessary to adhere to what one may term the natural groupings for the temperate zone. Looking at the annual values given in Table I., it will be seen that the greatest mean annual temperature variability, viz. 5°·9, was recorded during the "drift" of the *Belgica* in the ice-pack, this high value being closely followed by a mean of 5°·3 at the South Orkneys.

In the Victoria Land region, Ross Island and Cape Adair have a somewhat lower temperature variability of 4°·5, the values of the southern station being higher in summer and autumn, and lower in winter and spring than at the northern station. South Georgia occupies an intermediate position between a continental and an oceanic climate in its curve of variability, the mean monthly values varying according to the proximity of the pack-ice. At this station the seasonal values show a small variation, and this is also the case at Ushuaia in Tierra del Fuego. The variability at the Falkland Islands and New Year's Island is very small, pointing to the conserving influence exerted by the insular conditions which prevail at these places. The maximum variability occurs in winter, and the minimum in summer, at the three Antarctic stations as well as at South Georgia and the South Orkneys. The smallest variability at any season for any station occurs at the South Orkneys in summer, being only 1°·4. It is at this season that cloud amount and fog frequency are at a maximum, while at the same time rapidly moving cyclonic disturbances are of unfrequent occurrence.

Table II. gives for the six stations the data of which are analysed in full, the total number of cases (days) in which the mean daily temperature has changed from one day to the next, from 0°·1 to 2°·0, from 2°·1 to 4°·0, and so on. The strong contrast between summer and winter is a marked feature at the Antarctic stations and the South Orkneys, the greatest temperature variations taking place in the winter months. The smallest interdiurnal changes are the most frequent. Great rises of temperature take place more frequently than great falls. Positive changes of 35°·4 on the *Belgica*, and of 34°·6 at Ross Island, have been noted, while the greatest negative daily differences have been 34°·6 on the *Belgica* and 33°·2 at the South Orkneys. On the other hand, the maximum rise at Cape Pembroke, Falkland Islands, in two years was only 9°·4, and the greatest fall 8°·4.

Table III. shows the mean of all the rises and falls of temperature for the months and the year, while Table IV. gives the seasonal values. It will be seen that in almost every case the mean of the temperature rises is greater than the mean of the temperature falls. At Cape Adare in spring and at the Falkland Islands in winter the reverse of this is the case. The maximum excess of temperature rises over temperature falls on the mean of the year occurred at Ross Island, and on the *Belgica* the difference being 0°·7, while at the South Orkneys and South Georgia the difference was 0°·6. At Cape Adair the positive values show an excess of only 0°·2 over the negative, and at the Falkland Islands only 0°·1.

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TABLE II.—Analysis of Day to Day Temperature Changes.

Note.—Changes of 2° include differences of 0°·1 to 2°·0, of 4° from 2°·1 to 4°·0 and so on. On a very small number of days the temperature showed no day to day difference. These cases have not been taken account of.

South Orkneys, 2 Years.

	Rises.																	Falls.													
	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°	34°	36°	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°	34°	36°
January	26	7	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	19	7	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
February	16	7	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	25	6	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
March	16	10	2	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	16	6	8	0	0	0	1	...	...	...	...	...	...	...	...	...	...	...
April	9	6	3	2	6	0	2	0	0	0	1	...	...	...	...	...	...	...	12	5	3	4	1	3	1	1	0	0	1	...	...	...	...	...	...	...
May	8	4	2	2	1	2	3	0	1	0	1	2	1	1	1	...	...	...	4	5	8	3	5	2	3	0	0	2	1	...	...	...	...	...	...	...
June	3	5	6	2	2	1	1	1	0	5	0	1	2	...	...	...	...	...	3	7	4	1	4	3	1	0	3	1	0	2	1	0	0	0	1	...
July	8	1	4	2	3	4	0	1	0	0	1	1	1	1	1	...	...	...	4	5	4	8	5	0	2	1	2	1	1	0	0	1	...	...	...	...
August	2	4	4	5	7	1	3	0	2	0	1	0	1	0	0	1	...	...	7	5	2	2	5	1	1	1	1	2	1	1	1	1	...	...	...	...
September	7	3	3	6	4	2	0	0	0	2	1	0	0	0	1	...	...	...	7	6	1	4	3	6	2	1	0	1	...	...	...	...	...	...	...	...
October	6	9	6	1	1	1	3	0	0	2	0	0	1	...	...	...	...	...	11	5	5	4	1	3	1	0	0	0	2	...	...	...	...	...	...	...
November	15	5	2	1	2	...	...	...	...	...	...	...	...	...	...	...	...	...	23	6	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
December	23	5	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	27	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	139	66	37	22	27	11	12	2	3	9	5	4	6	2	3	1	...	...	158	68	42	26	24	18	12	4	6	7	6	3	2	2	0	0	1	...

"Discovery," Ross Island, 2 Years.

January	19	7	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	19	9	3	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
February	10	8	3	0	1	...	...	...	...	...	...	...	...	...	...	...	...	...	13	7	2	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...
March	14	7	3	6	1	0	1	...	...	...	...	...	...	...	...	...	...	...	10	5	6	4	3	0	0	1	0	0	1	...	...	...	...	...	...	...
April	9	5	7	3	0	1	2	...	...	...	...	...	...	...	...	...	...	...	9	8	5	6	1	1	1	1	...	...	...	...	...	...	...	...	...	...
May	7	6	5	1	3	3	1	1	1	0	0	1	1	...	...	...	...	...	9	6	6	4	3	2	2	...	...	...	...	...	...	...	...	...	...	...
June	5	3	4	6	2	1	0	0	0	2	0	1	...	...	...	...	...	...	7	11	7	3	6	0	2	...	...	...	...	...	...	...	...	...	...	...
July	10	5	1	2	2	0	0	0	0	0	3	2	1	...	...	...	...	...	7	9	5	4	4	4	1	1	...	...	...	...	...	...	...	...	...	...
August	8	5	4	1	3	3	0	1	0	0	0	0	0	0	1	0	0	1	8	5	6	6	4	2	1	3	...	...	...	...	...	...	...	...	...	...
September	7	4	2	4	4	1	3	0	0	2	1	...	...	...	...	...	...	...	6	10	6	7	1	1	0	1	...	...	...	...	...	...	...	...	...	...
October	10	6	2	3	1	2	1	1	1	...	...	...	...	...	...	...	...	...	13	8	6	5	1	1	...	...	...	...	...	...	...	...	...	...	...	...
November	13	10	4	3	3	...	...	...	...	...	...	...	...	...	...	...	...	...	10	7	3	3	4	...	...	...	...	...	...	...	...	...	...	...	...	...
December	14	9	5	2	0	1	...	...	...	...	...	...	...	...	...	...	...	...	15	9	6	0	0	1	...	...	...	...	...	...	...	...	...	...	...	...
Total	126	75	42	33	20	12	8	3	2	4	4	4	2	0	1	0	0	1	126	94	61	46	27	12	7	7	0	0	1	...	...	...	...	...	...	...

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TABLE II.—Analysis of Day to Day Temperature Changes—*Continued.*

"Belgica," 1 Year.

	Rises.																		Falls.															
	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°	34°	36°	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°	34°	36°
January	11	2	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
February	8	4	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9	3	1	0	1	...	...	...	...	...	...	...	...	...	...	...	...	...
March	3	3	2	1	2	1	0	1	...	...	...	...	...	...	...	...	...	...	9	2	1	2	0	1	0	1	1	...	...	...	...	...	...	...	...	...
April	2	2	1	3	0	0	0	1	0	1	1	0	0	0	1	...	...	...	5	2	2	1	1	1	2	2	1	0	1	...	...	...	...	...	...	...
May	3	1	2	2	2	1	0	0	2	...	...	...	...	...	...	...	...	...	4	4	4	1	0	1	1	2	0	1	...	...	...	...	...	...	...	...
June	3	2	2	1	3	0	2	3	0	1	1	...	...	...	...	...	...	...	0	1	2	3	0	1	1	1	1	0	0	0	1	0	0	1	...	...
July	6	1	4	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	3	2	5	3	0	1	1	0	0	0	1	0	0	0	0	0	0	1
August	2	1	2	0	1	1	0	1	0	1	1	1	1	1	...	...	...	...	4	3	1	1	4	1	1	1	1	1	...	...	...	...	...	...	...	...
September	4	1	4	1	1	0	0	0	0	0	2	0	0	2	0	0	...	...	2	3	3	0	3	0	0	3	1	...	...	...	...	...	...	...	...	...
October	4	1	3	2	1	2	...	...	...	...	...	...	...	...	...	...	...	...	6	6	0	3	2	1	...	...	...	...	...	...	...	...	...	...	...	...
November	7	4	1	3	2	...	...	...	...	...	...	...	...	...	...	...	...	...	5	2	2	3	1	...	...	...	...	...	...	...	...	...	...	...	...	...
December	8	4	0	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	11	3	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	61	26	23	16	13	5	2	7	2	3	6	1	1	3	1	0	0	1	71	34	23	18	12	7	6	10	5	2	2	0	1	0	0	1	0	1
Cape Adair, 11 Months.																																				
January	7	5	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9	4	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...
February	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
March	6	2	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7	6	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
April	4	4	1	1	1	1	1	...	...	...	...	...	...	...	...	...	...	...	4	4	4	3	2	...	...	...	...	...	...	...	...	...	...	...	...	...
May	2	4	2	3	1	1	0	0	1	...	...	...	...	...	...	...	...	...	1	5	3	2	2	3	1	...	...	...	...	...	...	...	...	...	...	...
June	1	2	3	0	3	0	2	0	1	0	0	1	...	...	...	...	...	...	3	5	2	1	1	2	0	1	1	1	...	...	...	...	...	...	...	...
July	1	1	2	3	3	1	1	0	0	1	1	1	...	...	...	...	...	...	4	1	2	0	3	2	2	1	0	0	1	...	...	...	...	...	...	...
August	2	4	1	1	1	2	1	2	1	...	...	...	...	...	1	...	...	...	0	2	2	2	3	1	1	3	1	...	...	...	...	...	...	...	...	...
September	4	5	0	2	1	1	0	1	1	...	...	...	...	...	...	...	...	...	1	3	4	2	1	1	0	2	1	...	...	...	...	...	...	...	...	...
October	3	8	3	5	0	0	1	...	...	...	...	...	...	...	...	...	...	...	2	0	5	2	0	2	...	...	...	...	...	...	...	...	...	...	...	...
November	2	7	1	2	1	1	1	...	...	...	...	...	...	...	...	...	...	...	7	4	2	0	2	...	...	...	...	...	...	...	...	...	...	...	...	...
December	10	3	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9	3	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	42	45	20	18	11	7	7	3	4	1	1	2	0	0	1	...	...	...	47	37	28	13	14	12	4	7	3	1	1	...	...	...	...	...	...	...

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TABLE II.—Analysis of Day to Day Temperature Changes—*Continued.*

Cape Pembroke, Falkland Islands, 2 Years.

	Rises.																		Falls.															
	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°	34°	36°	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°	34°	36°
January	10	7	3	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16	6	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
February	14	8	2	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	16	9	4	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
March	15	7	3	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	16	11	4	0	1	...	...	...	...	...	...	...	...	...	...	...	...	...
April	19	7	3	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9	14	3	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...
May	18	6	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20	9	3	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
June	13	9	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16	7	6	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
July	16	15	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13	9	4	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...
August	19	9	1	0	1	...	...	...	...	...	...	...	...	...	...	...	...	...	15	12	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
September	26	6	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13	10	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
October	19	9	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20	9	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
November	16	10	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20	10	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
December	17	12	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	18	8	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	202	105	32	8	3	...	...	...	...	...	...	...	...	...	...	...	...	...	192	114	38	7	1	...	...	...	...	...	...	...	...	...	...	...	...	...

South Georgia, 2 Years.

January	12	10	8	0	1	...	...	...	...	...	...	...	...	...	...	...	...	...	10	15	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
February	9	8	5	3	1	1	1	...	...	...	...	...	...	...	...	...	...	...	11	5	6	5	1	0	0	1	...	...	...	...	...	...	...	...	...	...
March	8	7	9	3	1	1	...	...	...	...	...	...	...	...	...	...	...	...	9	10	10	2	1	1	...	...	...	...	...	...	...	...	...	...	...	...
April	5	6	5	1	2	0	1	1	...	...	...	...	...	...	...	...	...	...	19	10	7	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...
May	8	7	8	1	2	2	1	...	...	...	...	...	...	...	...	...	...	...	14	6	6	4	2	0	0	0	0	1	...	...	...	...	...	...	...	...
June	14	5	7	0	0	2	...	...	...	...	...	...	...	...	...	...	...	...	16	4	4	3	4	1	...	...	...	...	...	...	...	...	...	...	...	...
July	6	9	3	3	3	1	1	1	...	...	...	...	...	...	...	...	...	...	12	5	9	5	1	1	0	0	1	...	...	...	...	...	...	...	...	...
August	7	5	1	6	3	3	1	1	0	1	...	...	...	...	...	...	...	...	11	5	7	5	3	1	1	0	0	1	...	...	...	...	...	...	...	...
September	7	6	3	6	0	0	2	3	...	...	...	...	...	...	...	...	...	...	11	8	5	2	4	0	2	1	...	...	...	...	...	...	...	...	...	...
October	9	10	5	2	2	0	1	...	...	...	...	...	...	...	...	...	...	...	11	15	5	0	2	...	...	...	...	...	...	...	...	...	...	...	...	...
November	15	6	2	4	0	0	0	0	0	0	1	...	...	...	...	...	...	...	16	8	5	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...
December	15	7	6	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	18	8	3	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	115	86	62	31	15	10	8	6	0	1	1	...	...	...	...	...	...	...	158	99	73	33	19	4	3	2	1	2	...	...	...	...	...	...	...	...

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TABLE III.—Showing for the Months and the Year the mean amount in degrees of Rises and Falls in Temperature.

	Discovery.		Cape Adair.		*Belgica.*		South Orkneys.		South Georgia.		Falkland Islands.	
	Rises.	Falls.	Rises.	Falls.	Rises.	Falls.	Rises.	Falls.	Rises.	Falls.	Rises.	Falls.
	°	°	°	°	°	°	°	°	°	°	°	°
January . .	2·0	2·1	2·3	2·2	1·6	1·2	1·3	1·7	3·0	2·8	2·5	1·9
February . .	2·8	2·8	...	...	2·1	2·1	1·7	1·3	4·0	3·9	2·4	2·3
March . .	3·5	5·0	2·3	2·2	5·5	4·6	2·3	2·6	4·1	3·6	2·4	2·4
April . .	4·0	4·5	4·8	4·5	9·7	7·5	5·4	4·9	4·8	2·5	2·3	2·6
May . . .	7·4	5·2	6·3	6·3	7·3	6·4	9·7	7·4	4·3	3·7	2·2	2·1
June . . .	6·9	5·0	8·8	6·9	9·0	12·3	9·8	9·9	3·0	3·5	2·4	2·3
July . . .	7·0	5·8	9·9	7·9	7·4	7·9	9·3	8·1	4·9	4·1	2·0	2·7
August . .	6·9	6·1	9·3	9·5	12·8	7·1	9·3	9·1	6·2	5·0	2·0	2·0
September .	7·0	4·6	5·4	7·4	9·3	7·8	7·6	6·9	5·5	4·6	1·8	2·0
October . .	5·1	3·5	4·6	5·8	5·1	4·2	6·3	5·4	3·6	2·9	1·9	1·8
November .	3·2	3·7	5·1	3·2	3·6	4·0	2·6	1·8	3·4	2·8	1·9	1·6
December .	3·0	2·5	2·1	2·0	2·7	1·8	1·4	1·1	2·5	2·3	2·2	1·9
YEAR . .	4·9	4·2	5·5	5·3	6·3	5·6	5·6	5·0	4·1	3·5	2·2	2·1

At Ross Island the monthly values show a distinct bi-annual period. The negative values are in some months greater than the positive, from November to April, while from May to October the positive values are greatly in excess of the negative. In other words, some force is at work

TABLE IV.—Showing for the Seasons the Mean Amount in degrees of Rises and Falls in Temperature.

Station.	Spring.		Summer.		Autumn.		Winter.	
	Rises.	Falls.	Rises.	Falls.	Rises.	Falls.	Rises.	Falls.
	°	°	°	°	°	°	°	°
Discovery . . .	5·1	3·9	2·6	2·5	5·0	4·9	6·9	5·6
Cape Adair . . .	5·0	5·5	2·2	2·1	4·5	4·3	9·3	8·1
Belgica . . .	6·0	5·3	2·1	1·7	7·6	6·2	9·7	9·1
South Orkneys . .	5·5	4·7	1·5	1·4	5·8	5·0	9·5	9·0
South Georgia . .	4·2	3·4	3·2	3·0	4·4	3·3	4·7	4·2
Falklands . . .	1·9	1·8	2·4	2·0	2·3	2·4	2·1	2·3

during the winter to cause large rises of temperature, and this force continues till well into the spring.

Table V. shows for each month the total number of cases in which the mean daily temperature was rising (+) or falling (−) continually during periods of from one to eight days. When a period began in one month and continued into the month following the values have been entered to the former month. In Table VI. the annual values have been expressed in percentages for periods of rising and falling temperatures as well as for both combined. The most frequent period is that of one day, the values ranging from 40 per cent at Ross Island to 51 per cent on the *Belgica*. Periods of two days are relatively frequent at South Georgia and the Falklands, and periods of three days are at a maximum in South Victoria Land and at a minimum at South Georgia. Periods of more than three

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TABLE V.—Number of Periods of Temperature Change in Days.

	"Discovery."															Cape Adair.													
	+							−								+						−							
Days	1	2	3	4	5	6	7	1	2	3	4	5	6	7	8	1	2	3	4	5	...	1	2	3	4	5	6	7	8
January	10	5	2	1	...	...	...	8	3	5	1	...	...	...	...	2	3	...	...	1	...	1	2	3	...	...	...	...	...
February	5	4	...	1	1	...	...	6	3	0	1	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
March	5	5	1	1	2	...	...	8	1	2	1	1	...	1	...	4	1	...	1	...	...	3	1	1	...	...	...	..	1
April	4	6	2	...	1	...	...	7	3	1	3	...	...	...	...	2	4	1	...	...	...	5	...	2	...	...	...	...	1
May	8	4	2	2	...	...	...	5	5	4	1	1	...	...	...	2	5	1	...	...	...	3	1	2	1	...	...	...	...
June	7	4	...	1	1	...	...	3	5	0	4	...	1	...	...	3	3	1	...	...	...	4	1	1	2	...	...	...	...
July	5	4	3	...	1	...	...	5	2	2	0	2	1	...	...	1	5	...	1	...	...	3	...	1	...	2	...	...	...
August	3	7	3	...	...	...	...	5	2	4	2	1	...	...	...	3	3	...	2	...	...	4	2	1	1	...	...	...	...
September	7	4	1	1	0	1	...	5	2	2	1	1	1	...	1	3	2	1	1	...	...	2	5	1	...	...	...	...	...
October	5	2	5	...	1	...	...	1	9	0	1	1	...	...	...	1	3	3	1	...	...	7	...	...	1	...	...	...	...
November	3	3	3	1	2	...	...	5	4	1	2	1	...	...	...	4	...	2	...	1	...	1	4	2	...	...	...	...	...
December	5	4	2	1	...	...	1	6	3	4	0	1	...	...	...	4	3	1	1	...	...	3	4	1	...	...	...	...	...
Total	67	52	24	9	9	1	1	64	42	25	17	11	3	1	1	29	32	10	7	2	...	36	20	15	5	2	...	...	2

	South Orknevs.															"Belgica."													
	+											▼				+						−							
Days	1	2	3	4	5	6	7	1	2	3	4	5	6	7	...	1	2	3	4	5	6	1	2	3	4	5	6	7	8
January	5	7	4	1	...	...	...	10	5	1	1	...	...	...	...	1	1	1	1	1	...	2	...	1	...	2	...	...	...
February	5	6	3	...	...	...	...	6	2	2	...	1	2	...	...	1	2	3	...	...	...	1	3	1	1	...	...	...	...
March	8	4	4	1	...	...	...	5	5	4	1	...	...	...	...	5	1	2	...	...	...	4	2	1	...	...	1	...	...
April	7	7	1	1	...	...	...	7	8	1	...	1	...	...	...	4	4	...	...	...	...	4	1	3	...	1	...	...	...
May	8	6	2	...	...	...	...	8	4	2	3	...	...	...	...	4	1	1	1	...	...	1	3	2	1	...	...	...	...
June	5	5	3	...	1	...	...	6	3	3	...	2	...	...	...	4	2	2	1	...	...	8	...	1	...	...	...	...	...
July	10	4	2	1	..	...	...	8	7	1	1	1	...	...	...	4	2	1	1	...	...	2	1	3	1	...	...	...	...
August	5	6	5	...	...	...	...	5	6	2	1	1	...	...	...	6	3	...	...	...	...	5	2	...	2	...	...	...	...
September	3	6	3	1	...	...	...	3	5	2	1	...	1	...	...	4	2	2	...	...	...	4	3	...	...	1	...	...	...
October	9	4	4	...	1	...	...	9	6	3	1	...	...	...	...	4	...	1	1	...	...	4	1	...	...	...	2	...	...
November	5	5	2	...	...	...	...	5	2	3	...	2	...	1	...	6	1	...	1	1	...	4	4	1	...	...	...	...	...
December	7	8	2	...	...	...	...	10	4	2	...	1	...	...	...	7	2	1	...	...	...	6	2	2	...	...	...	...	...
Total	77	61	35	5	2	...	...	82	57	26	9	9	3	1	...	50	21	14	6	2	...	45	22	15	5	4	3	...	...

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TABLE V.—Number of Periods of Temperature Change in Days—(*Continued*).

	Falkland Islands.															South Georgia.												
	+							−								+						−						
Days	1	2	3	4	5	6	7	1	2	3	4	5	6	7	...	1	2	3	4	5	6	1	2	3	4	5	6	7	8
January	9	5	1	...	...	...	...	10	4	...	1	...	...	...	...	11	5	2	1	...	...	11	5	2	1	...	...	...	...
February	7	5	2	...	1	...	...	8	3	2	1	...	1	...	...	7	9	1	...	...	...	9	7	3	...	...	...	...	...
March	11	3	2	...	1	...	...	10	7	...	2	...	...	...	...	5	8	3	...	...	...	6	4	4	1	...	...	...	...
April	6	1	4	2	...	...	...	4	4	4	1	...	...	...	...	12	4	...	...	...	...	5	4	2	4	1	...	...	...
May	7	7	3	...	...	...	...	9	5	1	1	...	...	1	...	7	3	2	1	...	1	4	3	4	...	2	...	...	...
June	10	3	2	...	...	1	...	8	4	4	1	...	...	...	...	6	3	4	1	...	...	7	3	3	1	1	...	...	...
July	3	6	1	2	1	...	...	5	4	3	1	...	...	...	...	7	6	2	1	...	...	6	3	3	2	1	...	...	...
August	4	9	3	...	...	...	...	7	8	2	...	...	...	...	...	11	4	2	...	...	...	10	5	2	...	...	...	...	1
September	13	4	3	1	...	...	...	16	4	1	...	...	...	...	...	12	3	3	...	...	...	7	7	1	1	1	...	...	...
October	8	2	4	1	1	...	...	8	4	3	1	...	...	...	...	12	5	...	1	1	...	10	6	4	...	...	...	...	...
November	4	5	2	1	...	...	...	5	3	3	1	2	...	...	...	6	7	3	...	...	...	2	9	2	...	1	...	...	...
December	8	4	4	1	...	...	...	9	6	...	1	1	...	...	...	14	3	3	...	...	...	13	3	4	...	...	...	...	...
Total	90	54	31	8	4	1	...	99	56	23	11	3	1	1	...	110	60	25	5	1	1	90	59	34	10	7	...	...	1

TABLE VI.—Annual Percentage Frequency of Days (Periods) of Different Duration.

	Temperature Rising.							Temperature Falling.								Temperature Rising and Falling.							
Days	1	2	3	4	5	6	7	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Discovery	41·1	31·9	14·8	5·5	5·5	0·6	0·6	39·0	25·6	15·3	10·4	6·7	1·8	0·6	0·6	40·0	28·7	15·0	8·0	6·1	1·2	0·7	0·3
Cape Adair	36·3	40·0	12·5	8·8	2·4	...	...	45·0	24·9	18·8	6·3	2·5	...	...	2·5	40·6	32·5	15·6	7·5	2·5	...	...	1·3
South Orkneys	42·8	33·9	19·4	2·8	1·1	...	...	43·9	30·5	13·9	4·8	4·8	1·6	0·5	...	43·3	32·2	16·6	3·8	3·0	0·8	0·3	...
Belgica	53·8	22·5	15·0	6·5	2·2	...	...	47·8	23·4	15·9	5·4	4·3	3·2	...	...	50·8	23·0	15·5	5·9	3·2	1·6	...	...
Falkland	57·9	28·7	16·5	4·3	2·1	0·5	...	51·0	28·9	11·9	5·7	1·5	0·5	0·5	...	49·4	28·8	14·2	5·0	1·8	0·5	0·3	...
South Georgia	54·5	29·7	12·4	2·4	0·5	0·5	...	44·8	29·4	16·8	5·0	3·5	...	0·5	...	49·7	29·6	14·6	3·7	2·0	0·2	...	0·2

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TABLE VII.—Showing the Mean Duration in Days of Periods of Rising and Falling Temperature and the Sum of these Periods.

	Discovery Ross Island.			Cape Adair.			*Belgica*.			South Orkneys.			South Georgia.			Falkland Islands.		
	Rises.	Falls.	Sum.	Rises.	Falls.	Sum.	Rises.	Falls.	Sum.	Rises.	Falls.	Sum.	Rises.	Falls.	Sum.	Rises.	Falls.	Sum.
January . .	1·7	1·9	3·6	2·2	2·3	4·5	3·0	3·0	6·0	2·1	1·6	3·7	1·6	1·6	3·2	1·5	1·5	3·0
February . .	2·0	2·3	4·3	...	...	...	2·3	2·3	4·6	1·9	2·5	4·4	1·6	1·7	3·3	1·9	2·0	3·9
March . . .	2·3	2·3	4·6	1·7	2·7	4·4	1·6	1·9	3·5	1·8	1·8	3·6	1·8	2·0	3·8	1·6	1·7	3·3
April . . .	2·1	2·0	4·1	1·9	2·4	4·3	1·5	2·2	3·7	1·9	2·1	4·0	1·2	2·5	3·7	2·2	2·2	4·4
May . . .	1·9	2·2	4·1	1·9	2·1	4·0	1·9	2·4	4·3	1·6	2·0	3·6	2·1	2·5	4·6	1·8	1·9	3·7
June . . .	1·8	2·7	4·5	1·7	2·1	3·8	2·0	1·2	3·2	2·1	2·2	4·3	2·0	2·1	4·1	1·8	1·9	3·7
July . . .	2·1	2·6	4·7	2·1	2·7	4·8	1·9	2·4	4·3	1·6	1·9	3·5	1·8	2·3	4·1	2·4	2·0	4·4
August . .	2·0	2·4	4·4	2·1	1·9	4·0	1·3	1·8	3·1	2·0	2·1	4·1	1·5	1·9	3·4	1·9	1·7	3·6
September .	2·0	2·9	4·9	2·0	1·9	3·9	1·9	1·9	3·8	2·1	2·4	4·5	1·5	1·9	3·4	1·6	1·3	2·9
October . .	2·2	2·3	4·5	2·5	1·4	3·9	1·8	2·6	4·4	1·9	1·8	3·7	1·6	1·7	3·3	2·1	1·8	3·9
November . .	2·7	2·2	4·9	2·1	2·1	4·2	1·9	1·7	3·6	1·8	2·7	4·5	1·8	2·2	4·0	2·0	2·4	4·4
December . .	2·3	2·1	4·4	1·9	1·8	3·7	1·4	1·6	3·0	1·7	1·7	3·4	1·4	1·6	3·0	1·9	1·8	3·7
Year . . .	2·1	2·3	4·4	2·0	2·1	4·1	1·9	2·0	3·9	1·9	2·0	3·9	1·7	1·9	3·6	1·9	1·9	3·8
Summer . .	2·0	2·0	4·0	2·0	2·0	4·0	2·0	2·1	4·1	1·9	1·9	3·8	1·6	1·6	3·2	1·7	1·7	3·4
Autumn . .	2·1	2·2	4·3	1·8	2·4	4·2	1·8	2·2	4·0	1·8	2·0	3·8	1·7	2·3	4·0	1·8	1·9	3·7
Winter . .	2·0	2·6	4·6	2·0	2·2	4·2	1·7	1·8	3·5	1·9	2·1	4·0	1·8	2·1	3·9	2·0	1·9	3·9
Spring . . .	2·3	2·5	4·8	2·2	1·8	4·0	1·9	2·0	3·9	1·9	2·2	4·1	1·6	1·9	3·5	1·8	1·8	3·6

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days comprise 16 per cent of the cases at the former and only 6 per cent at the latter station, these being the extremes.

Table VII. shows the mean duration in days of these periods of rising and falling temperature for the months, seasons, and the year, as well as their sum. The sum of the periods on the mean of the year ranges from 3·6 days at South Georgia to 4·4 days at Ross Island. Temperature rises in general more slowly than it falls, this being also the case in the Arctic regions in high latitudes. (See Mohn's *Report on the Meteorology of the "Fram" Norwegian North Polar Expedition*, "Scientific Results," vol. vi. p. 492.)

Table VIII. shows the seasonal percentage frequency of rises and falls of temperature. It will be observed that at every station there are more falls than rises, the excess being greatest (8 per cent) at South Georgia and least (0·2 per cent) at the Falkland Islands. For the *Discovery*, Cape Adair, and the South Orkneys, the excess is nearly of the same amount at all three places. Perhaps the most interesting point disclosed by an inspection of the seasonal values is the relatively large percentage of days with falling temperature during the winter season at Ross Island and South Georgia, the same being characteristic of the autumn months at Cape Adair, on the *Belgica*, at the South Orkneys, and South Georgia. On the other hand, the frequency of temperature rises at Cape Adair in spring is more pronounced than at any other station during any season of the year.

TABLE VIII.—Seasonal Percentage Frequency of Rises and Falls of Temperature.

	Discovery.		Cape Adair.		*Belgica.*		South Orkneys.		South Georgia.		Falkland Islands.	
	+	−	+	−	+	−	+	−	+	−	+	−
Spring .	48·7	51·3	55·0	45·0	49·5	50·5	46·5	53·5	46·2	53·8	51·4	48·6
Summer .	48·6	51·4	51·0	49·0	47·8	52·2	49·4	50·6	49·4	50·6	48·5	51·5
Autumn .	48·6	51·4	43·2	56·8	41·8	58·2	45·1	54·9	42·9	57·1	48·6	51·4
Winter .	42·1	57·9	47·9	52·1	49·0	51·0	47·9	52·1	45·4	54·6	50·9	49·1
Year . .	46·9	53·1	49·1	50·9	47·0	53·0	47·2	52·8	46·0	54·0	49·9	50·1

Temperature Variability at a Pole of Cold.

In order to get some idea of the variability of temperature at a pole of cold I have analysed the winter data at Verkhoïansk[1] (lat. 67° 10′ N., long. 157° 10′ E.) for the months of January, February, and December for the years 1900-1902.

The values are as follows:—

Month.	Variability.			Period.		
	Rises.	Falls.	Weighted Mean.	Rising.	Falling.	Sum.
	°	°	°	Days.	Days.	Days.
December . .	10·7	10·0	10·2	1·7	2·0	3·7
January . .	6·6	6·9	6·7	2·1	1·7	3·8
February . .	8·9	8·4	8·7	1·8	2·0	3·8
Mean . .	8·7	8·4	8·5	1·9	1·9	3·8

[1] Daily mean temperatures are given in *Annales de l'Observatoire Physique Central Nicolas*, publiées par M. Rykatchew, II. partie, for the years specified.

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Hence at the Siberian pole of cold the winter temperature variability is much the same as at the South Orkneys and the region covered by the drift of the *Belgica*. While this is so, yet from time to time temperature changes of a magnitude of which we have no record from the Antarctic take place. Thus the mean temperature of December 3, 1901, was no less than 51°·3 higher than the mean of the previous day, and this great rise was followed by a fall of 33°·7 in the mean temperature of December 4. It is not unlikely that such great changes are also characteristic of the Antarctic cold pole, as the passage of a very deep depression even 600 or 800 miles to the north could hardly fail to produce a great disturbance of thermal conditions in the anti-cyclonic region.

Temperature Variability in a Sea covered with Ice in Summer.

It may be of interest to give the results of an analysis of the variability of temperature in summer in the Greenland Sea area based on observations extending over 15 Mays, 16 Junes, and 11 Julies. For May and June the data are complete, but July gives an average of 24 days' observations per month. (See "The Greenland Sea, its Summer Climate, and Ice Distribution," *Scottish Geographical Magazine*, June 1909.)

The values are as follows for a mean position of about 77° N. latitude and 5° of E. longitude.

Month.	Temperature Variability.			Period.		
	Rises.	Falls.	Weighted Mean.	Rising.	Falling.	Sum.
	°	°	°	Days.	Days.	Days.
May . . .	3·3	3·2	3·2	2·1	1·8	3·9
June . . .	2·0	1·9	1·9	1·9	1·6	3·5
July . . .	2·0	1·5	1·6	1·6	2·0	3·6
	2·4	2·2	2·3	1·9	1·8	3·7

These results are in close accordance with the values given by Mohn[1] for the *Fram* Expedition. It will be seen that in July the mean period of falling temperature was greater than that of the rising temperature, and this also agrees with Mohn's results.

The percentage frequency of periods during which temperature rose or fell for the above three months is given in the following table. The longest period of rising temperature is 8 days and of falling temperature 5 days.

Days	1	2	3	4	5	6	7	8	No. of Periods.
	%	%	%	%	%	%	%	%	
+	43·7	30·5	12·5	7·7	3·3	1·1	0·6	0·6	183
−	50·7	33·1	10·3	4·9	1·0	...	...	...	205
±	47·4	32·0	11·3	6·1	2·1	0·5	0·3	0·3	388

Hence it will be seen that in nearly 80 per cent of the cases the periods were one or two days.

DISCUSSION.

Mr. W. W. Bryant said he thought the paper would have been more valuable had there been a longer period for discussion. As it was, it would be

[1] *Norwegian North Polar Expedition*, "Scientific Results," vol. vi. pp. 488-492.

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difficult to accept all the conclusions arrived at by Mr. Mossman. It was interesting to find, as at Greenwich, a sudden great rise of temperature more frequent than a sudden great fall. A change of 51° in mean temperature from day to day would be decidedly uncomfortable.

Colonel H. E. RAWSON said he considered the paper an exceedingly interesting one. He was very anxious to get more data of the temperature in those regions, because the oscillation of the belt of high pressure in the Southern Hemisphere seemed to be related to the ice-drift. When the high-pressure belt was far north, the ice was also found far north, but when the belt over South Africa was far south, then the ice-drift everywhere was also far south, and this evidently would affect the temperature of those regions. The record of the very great difference in the mean temperature reminded him of Canada, where a change of 45° produced rather startling results. The nails in woodwork would fly out from the wall suddenly; while he had seen a white tie that had been washed break whilst being tied.

Dr. W. N. SHAW said Mr. Mossman was to be commended for the industry and ability with which he had discussed the matters in his paper. He, Dr. Shaw, was curious to know why a period of days had been selected. These variations were remarkably spasmodic: there would be a sort of river of cold air, suddenly met and swept away by another river of hot air, and *vice versa*. These rivers obeyed no sun or moon, and were entirely non-periodic. He should suppose the difference occurring within the limit of 24 hours to be the same as the difference occurring between the temperature of one day and another day. It would be interesting to know if Mr. Mossman had really got the correct facts when dealing with the change of mean temperature in 24 hours. If one took the difference between the mean maximum and minimum for the day, the range was large, but if the average of the readings of the corresponding hours were taken, then the daily range was hardly noticeable. Dr. Chree, with the aid of mathematical instruments, had taken a very long time to determine whether there was a true diurnal variation or not. Should not these variations be got out for two days? This had of course not been attempted in the paper, and it would be very difficult to undertake on the periodic variation taken at present. He thought it would have been interesting to have taken the diurnal variation as well as the interdiurnal.

Mr. W. B. TRIPP said it was interesting to hear Col. Rawson's remarks on the effect of the sudden changes of temperature. Similar phenomena are said to occur in South America, and the sudden changes of temperature from heat to cold were often particularly noticeable during the Pamperos in Buenos Aires by those exposed to them. Sudden changes of temperature were said to cause glass to crack, etc., also to produce personal distortions—he had not himself witnessed such startling effects—causing a kind of "stroke" or "ayrie," as it is locally designated.

Mr. W. MARRIOTT remarked that Mrs. Mossman had come over from the Argentine, and had hoped to have been present at the Meeting, but she was detained in Edinburgh. She, however, said in her letter that Mr. Mossman had written saying that he had discovered a monsoon off the coast of Chili, which he considered the best piece of work that he had done.

The PRESIDENT said he knew all present would wish the thanks of the Society to be conveyed to Mr. Mossman for his able and interesting paper. Mr. Bryant's remarks illustrated what happened to any one taking up a piece of meteorological work. In spite of all the data collected, there was always more required.

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TESTING OF REGISTERING BALLOON APPARATUS AT LOW TEMPERATURES.

By Dr. W. SCHMIDT and ERNEST GOLD, M.A., F.R.Met.Soc.

[Read June 16, 1909.]

The following experiments were made with a view to ascertaining if appreciable errors could enter into the temperatures recorded in balloon ascents owing to errors in the alcohol-CO_2 method of testing the apparatus. For this purpose a pair of thermo-elements was used. It consisted of a single nickel wire which was soldered at both ends to copper wires, the circuit being completed through the galvanometer. The ends of the thermo-elements were enclosed in glass tubes so that the points only were exposed, and these were insulated by a layer of paraffin-wax thin enough to prevent it influencing considerably the lag of the arrangement.

Determination of the Sensitiveness of the Thermo-element Arrangement.

The following table gives the results of one determination. The thermo-elements were immersed in water-baths at different temperatures, and the water was stirred until the galvanometer reading did not change. The elements were then interchanged and a fresh reading taken.

Element A.	Element B.	Galvanometer.
17·0 C.	13·0 C.	9·3 cm.
13·2	17·0	20·8
21·2	14·5	5·8
14·6	20·9	24·5

This determination was made before the experiments at low temperatures, and the points were enclosed in thin rubber, afterwards replaced by paraffin-wax.

A second determination, made after the experiments, furnished the following values, which are perhaps more reliable.

Element A.	Element B.	Galvanometer.
17·8 C.	10·7 C.	2·6 cm.
10·9	17·4	23·5
17·0	10·9	4·4
11·0	16·8	22·4
14·8	12·1	10·0
12·2	14·7	18·0

The sensitiveness has, therefore, increased slightly. The first series gives a scale difference of 2·92 cm. for 1° C. temperature difference; the second series gives 3·06 cm. These values are valid, however, only for temperatures of 13°-14° C. since the thermo-electric force of the combination Cu.-Ni. is dependent on the temperature. If we take the numbers given by Fleming and Dewar, we find that for a temperature of − 60° C., at which the later experiments were made, the sensitiveness is about 75 per cent of its value for 13°-14° C., so that in our case the

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scale difference at the lower temperature would be about 2·30 cm. for 1° C. temperature difference.

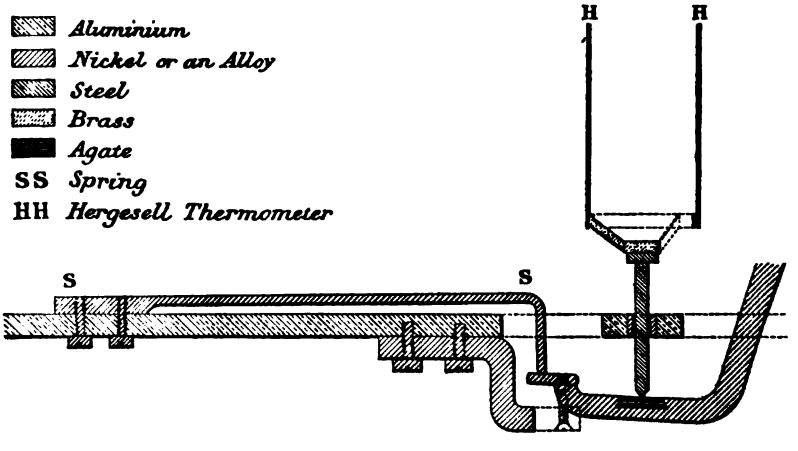
The following series shows that the "zero" was practically independent of the temperature, and that therefore no disturbing thermo-electric forces entered at other places than at both elements.

Temp. of Bath.	Zero Point.
°	
12·2 C.	14·3 cm.
14·2	14·3
24·4	14·4
14·5	14·3
23·5	14·35

Investigation of the Possible Errors in Testing the Thermometers of the Registering Balloon Apparatus.

The alcohol-CO_2 bath is contained in a rectangular trough 34 cm. long, 13·5 cm. wide, and 18 cm. deep. To prevent rapid temperature variations the trough is set in a larger box 50 cm. × 30 cm. × 36 cm., and the interspace is filled with wadding. This protection proves quite sufficient, the temperature varying very slowly when the bath is left to itself.

The apparatus (Bosch) is set vertical in the bath with the bimetal thermometer just above the bottom, and the Hergesell Tube Thermometer about 3 cms. beneath the upper surface of the fluid. The upper end of the Hergesell thermometer is only 3 cm. from the right end-wall of the bath. Near the left end, between the bottom of the apparatus and the



Section of the Instrument.

end of the bath, is a fan consisting of two blades on an horizontal axis which is rotated by hand, the speed being increased by a cog-wheel arrangement. In an ordinary test the process is from higher to lower temperature in steps as the CO_2 snow is put into the bath. The apparatus remains in the bath the whole time, except while the CO_2 snow is being

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poured in. But when there is more than one instrument, each apparatus is put in separately for each different temperature, and remains in only a short time, until it appears to have taken up the temperature of the bath.

By this procedure it appeared possible that errors might arise in the following ways :—

(1) The stirring might be insufficient to ensure the temperature being the same throughout the bath.

(2) The stirring might be sufficient for the bath alone, but might be insufficient to bring the apparatus to the same temperature, so that the actual temperatures of both thermometers might be different, and different to that shown by the alcohol thermometer.

(3) Owing to the fact that part of the apparatus was always in the warmer air above the bath, it was possible that conduction of heat might introduce errors into the results.

To test (1) one thermo-element was put about 3 cm. above the bottom of the trough, and the other about the same distance below the surface of the fluid. The galvanometer reading was 18·6 cm., and after interchanging the thermo-element 13·4 cm., showing a slight temperature difference. But this became smaller as soon as the fan, which had been rotated only a short time, was again set in motion. The readings became 13·8 cm. and 14·9 cm., and were independent of the direction of rotation of the fan. Thus in the first case the temperature difference amounted to nearly 2°·3 C., and in the latter to only 0°·5 C., the upper element being in all cases the warmer.

To test (2) one thermo-element was put inside the protecting case of the bimetal thermometer, the other in front of the upper opening of the Hergesell thermometer, midway between it and the wall of the trough.

Readings with this arrangement	and	with Elements interchanged.
14·1 cm.		16·1 cm.
13·5		16·1
	and in a later experiment	
13·5		15·1
14·1		15·1

These show a temperature difference of about 0°·8 C., the upper element, in front of the Hergesell thermometer, being the warmer. The differences are, however, as their variability shows, of an accidental nature.

In another experiment the second thermo-element was put right inside the Hergesell thermometer. This, of course, prevented free circulation and increased the apparent lag, so that, in fact, the galvanometer reading only became steady after twice as long a time. The difference between the readings was much smaller, namely, 14·5 cm. and 14·85 cm., corresponding to a temperature difference of about 0°·2 C. In this case the element inside the Hergesell thermometer showed the *lower* temperature.

To see if there was any appreciable difference between the temperature of the alcohol thermometer and the rest of the bath, one element was put in contact with the alcohol thermometer, and the other as above in the bimetal.

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The readings were—

13·7 cm.	14·6 cm.
...	14·4
...	14·3
13·8	14·8

showing a temperature difference of about 0°·3 C. only.

An experiment to test the effect of conduction of heat showed that the metal frame, to which the various parts of the apparatus are fixed, had a slightly higher temperature near the bottom of the Hergesell thermometer owing to the higher temperature of the part not in the bath. But a little lower down in the bath this effect was absent, and none of the apparatus fixed to the frame showed any trace of it. The thermometric elements were certainly not affected by such a cause.

The results of these experiments would therefore lead us to suppose that the differences between the records of different thermometers in balloon ascents arise from peculiar conditions in the upper air.

There is, however, an effect which appears to have been hitherto overlooked, and which implies a fault in the construction of the otherwise excellent Bosch type of instrument. It arises from the construction of the spring which presses the multiplying lever of the tube thermometer against the counterpoise. This spring is fixed under the clock on the upper side of the frame, and only a small part of it is actually in the bath during a test. But its elasticity and expansion depend on its temperature, and since small variations arising from changes in it are magnified in the same degree as the variations in the length of the tube itself, it is clear that they call for consideration. To show the sort of effect that might arise in this way the following experiment was made:—The apparatus was held in the normal position with the frame horizontal, and was put in the bath only far enough to cover part of the spring mentioned, but not far enough to immerse any part of the thermometric elements themselves. Instead of the instrument recording a slight diminution of temperature, or no change at all as might have been expected, it showed a comparatively rapid increase and became steady only after rising 2° or 3° C.

The spring, as already observed, was not immersed throughout its whole length, so that the full effect of such immersion would be considerably greater. But the order of magnitude is sufficient to show that we have here a source of appreciable error which cannot be eliminated by testing the apparatus, because it depends on the lag of the various parts of the apparatus in taking up the temperature of the air during any particular ascent. Disturbing influences of this kind clearly affect most of the instrument for which the magnification is greatest, *i.e.* for the Bosch instrument the tube thermometer. Stricter experiments on this point will be made later.

In conclusion, it may be well to point out that, for a test in an alcohol bath to be sufficiently accurate at low temperatures, the stirring must be vigorous and nearly continuous. The difference of temperature between the upper and lower parts of the bath increases rapidly if there is no stirring. An experiment showed that even apart from the lag of the thermo-elements this increase was as great as 1° C. per minute.

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Note added June 4.

On May 29, 1909, the Bosch apparatus (No. 120), with which the previous experiments had been made, was again tested with the cold bath. The clock was taken off and the instrument held obliquely so that the whole of the spring of the Hergesell thermometer was immersed, but none of the thermometer itself. The temperature of the latter changed only slowly, owing to conduction in the supports, and perhaps also through contact with the cooler air over the bath. Thus after immersion in the cold bath in the manner described, the recording pen, read against a millimeter scale, indicated a comparatively rapid rise of temperature followed by a slow fall. The reading was taken when the apparent temperature was a maximum, and the apparatus was then similarly immersed in a bath at about room-temperature and the corresponding reading taken. The time between immersion and reading was in all cases about 1 minute, which would roughly correspond to the time necessary for the spring to take up the temperature of the bath.

Temperatures of Baths.		Corresponding Readings.	
−52° C.	10°·5 C.	7·2 mm.	2·8 mm.
−50 ,,	9·0 ,,	6·4 ,,	2·2 ,,
−49 ,,	8·0 ,,	6·4 ,,	2·4 ,,
−48 ,,	7·5 ,,	6·2 ,,	1·8 ,,
−48 ,,	6·2 ,,	6·0 ,,	1·8 ,,

Thus a variation in the temperature of the spring of about 58° C. corresponds to a difference of 4·2 mm. nearly. Now the thermometer scale is approximately 0·8 mm. for 1° C., so that the above difference represents an error of about 5°·3 C.

Now in an actual ascent the spring is not well ventilated, owing to its position under the clock, and there will in general be a difference of temperature between it and the thermometric element. The tendency will be for the latter to be cooler in the ascent and warmer in the descent. The recorded temperature would therefore be too low in the ascent and too high in the descent. Of course the values deduced for the temperature from the record depend on the testing of the instrument, and are complicated by the fact that, in tests with the alcohol bath the whole of the spring is not immersed, but only a part. In such a case the tendency would be for the temperature (deduced from the record by comparison with the bath calibration) to be too high, and for the error to increase as the actual temperature decreased. Apart from the effects of lag the difference would be in the same direction, both in ascent and in descent.

DISCUSSION.

Mr. F. Campbell Bayard considered the paper an extremely important one, and asked what was the result of the experiments on the observations obtained in the upper atmosphere? Were they to conclude that the observations obtained by the instruments were as perfect as could be expected, or should they take it that the observations were useless because of the imperfection of the instruments?

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Mr. W. W. Bryant inquired which of the thermometers was found to have the smaller lag, as this would presumably be the better instrument to use, and the point should obviously be kept in view by the designers and makers of such instruments.

Mr. C. J. P. Cave said he had never tested a thermometer of the kind used by Mr. Gold. He thought the paper an extremely interesting one, because it showed how very careful one had to be with instruments of this kind. In reply to a query about the testing of the Dines instrument, Mr. Cave gave an explanation, illustrated by a rough diagram, of the method employed.

Dr. W. N. Shaw said the practice in this country was to use carbonic acid and petrol for testing instruments. The Dines thermometer was dipped completely in. He further remarked that Dr. Chree, in a letter to *Nature*, had practically discredited the observations in the upper air, consequently any definition of the position of the instruments used must be welcomed.

Mr. E. Gold said in reply that the results hitherto obtained were certainly very valuable. They had revealed the existence of the remarkable phenomenon, usually termed the isothermal layer, in which there was practically no vertical temperature change. But more information was needed regarding what occurred in that region, and until we were quite certain of the behaviour of the thermometers we should be in doubt as to whether peculiarities shown in the record were real or no.

In reply to Mr. Bryant's query Mr. Gold said it would be difficult to answer this point. In the bath the bimetal thermometer showed the smaller lag, but that was probably due to the fact that the alcohol circulated more freely about it than about the Hergesell instrument. In the upper atmosphere that might not be the case.

There was no question about the comparison of the instrument with a reliable thermometer; that was done in all cases he believed, the instrument being compared with an alcohol thermometer standardised at a central physical institute. The temperature at the beginning of the experiment in the paper was about -62° C.

The President said they were all indebted to Mr. Gold for his paper, which showed clearly how extremely important a point the accuracy of the instruments was if the observations were to be reliable. He only regretted that Mr. Gold had not experimented with the instrument most in use in this country, the Dines meteorograph.

Snowstorms and Parapets on Buildings.

The heavy snowstorms which occurred during March were the means of illustrating to residents in towns the nature of avalanches. The object lesson was not always pleasant or unattended with risk to life and limb, for the accumulation of masses of snow on the roofs of houses and premises adjacent to public thoroughfares which came down upon the public footways and on the heads of pedestrians when a thaw set in, was decidedly disconcerting and dangerous. The experience thus gained has led many Councils to consider as to what steps should be taken to provide against the danger, and one Council, the Sevenoaks Urban, have been so far moved as to apply to the Local Government Board for sanction to a by-law providing that the Council may, if they consider it necessary, for the public safety, require that a parapet wall shall be erected on such parts of new buildings as abut on a street or footway—such parapet wall having a properly constructed gutter behind it. The building by-laws of Local Authorities have only provided for parapet walls to buildings of a certain height and class as a protection against fire from adjacent premises.—*Sanitary Record*, *April* 1, 1909.

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A PLEA FOR THE USE OF FREELY-EXPOSED THERMOMETERS IN ADDITION TO SHELTERED ONES.

By L. C. W. BONACINA, F.R.Met.Soc.

[Read June 16, 1909.]

Meteorologists have hitherto founded their main facts and ideas of climatology, in so far as temperature records are concerned, solely upon the temperature of the air as registered approximately by shaded thermometers enclosed usually within a Stevenson screen, which is supposed to eliminate all direct radiation effects. Thus most of our temperature quotations comparing place with place, or season with season, and all our isothermal maps, refer to this same condition—the temperature of the air.

Fortunately it is possible and practicable to record the temperature of the air with sufficient accuracy for meteorological purposes; and as the temperature of the air so greatly affects the welfare of the living world, it is well that the subject should have been studied in this and many other countries with such thoroughness. But the temperature of the *air* is not the only condition which enters practically into our notions upon climate and the relative "hotness" or "coldness" of the *atmosphere* at different times and places. The gain and loss of heat to the earth by radiation profoundly influences, of course, the living world, and direct radiation superimposed upon the actual temperature of the air enters enormously into our perception of how hot or cold it is at a given moment. The temperature of the soil, for instance, besides influencing physiological sensation by direct radiation effects (when as sometimes happens it differs from that of the air) is of great agricultural importance, and although it largely controls the temperature of the air, is itself in great measure controlled by direct solar or terrestrial radiation. It should be noted in this connection that while the ground temperature must differ little on an average from the air temperature at 4 feet above the ground, there are yet many occasions when the divergence between the two conditions is very considerable as during the "radiation weather" of an anti-cyclonic circulation of the air. But of fundamental importance, as regards our personal estimate of climate as well as the physiological sensations of the whole animal and vegetable kingdoms, is, of course, direct *solar* radiation. To use the phrase "temperature in the sun" is convenient, provided we bear in mind that the extent to which the temperature is raised of the surface of any body on the earth's surface (which may, of course, be the bulb of a thermometer or the human face) exposed to direct solar radiation of given intensity, depends upon the nature of the body as well as upon the windiness and temperature of the air [1] in contact with it. Similarly with respect to the exposure of bodies to direct terrestrial radiation. Our personal estimate, therefore, of how hot or cold it is at any moment depends upon *the actual temperature of the air plus the*

[1] I have purposely omitted its relative humidity, for since the dampness of the air is effective in absorbing radiation to and from the earth, the actual intensity of solar radiation experienced at the surface varies inversely as the dampness.

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totality of radiation effects from sun and soil. We have now, then, a broader notion of climate than that based upon the consideration of air temperature alone. Consequently theory demands that we should try to develop this aspect of the study of climatology—not indeed instead of air temperature, but together with it—by making observations with thermometers freely exposed to sun, wind, and soil in an open space. Let the propriety of this be considered. Now a sunny day with an air temperature as recorded on a Glaisher stand or in a Stevenson screen of, say, 55° only, is in a broader sense a hotter day than an overcast day with an air temperature as high as 65°, and from the point of view of the needs of vegetation is very effectually a hotter day.

Again, we have the curious fact that in the insular climate of Britain, where the seasonal changes of mean air temperature lag behind the changes in the altitude of the sun more than they do in continental countries, the mean temperature of the air in the month of April—a month when the sun being already vertical north of the equator the days are longer than the nights and solar radiation powerful—is from 2° to 3° lower than in October, a month of feeble radiation from the sun and short days. Despite, however, the lower air temperature, April is to be regarded in a more liberal sense as the hotter month of the two. Moreover, that the duration and intensity of solar light and heat are of more consequence to animals and plants than mere air temperature (provided, of course, that the two conditions are not enormously at variance—the temperature of the air is a variable function of the duration and intensity of solar radiation) is proved by the fact that in April we witness the rapid spring and growth of wild life, and in October its equally rapid fall and decay.

If therefore freely exposed thermometers were to be installed at meteorological observing stations side by side with the sheltered ones, a valuable addition to our knowledge of climate would eventually result, and it would be found that places and times according to the readings of the sheltered thermometers would not compare with one another in exactly the same way as according to the readings of the exposed thermometers.

Against the proposal to establish freely-exposed thermometers, it will probably be argued that great difficulty would be experienced in choosing a site of installation free from the accidental radiations from walls, banks, inequalities of ground level, etc. It would, of course, be necessary to select a site as free as possible from such disturbing features; and since the nature of the soil or ground is itself something of a climatic factor, care would have to be taken to choose a surface that could be regarded as typical or representative of the locality in which the observations were to be made. Thus, in most English rural districts a *grass* surface away from buildings would be the appropriate choice of site. But in London and other large tracts of paved surface, where the area is so large as to constitute an important geographical feature, and to impose a local modification upon atmospheric conditions, a paved surface might form a more appropriate observing site than a grass one, unless the site were chosen in a park.

Similarly in localities—not very common in England outside towns—where the predominant surface was not grass, the kind of surface that was predominant would have to be selected over which to instal the

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exposed thermometers. In a very hilly or mountainous district where the ground is much broken up, the natural conditions of its locality would not require or indeed allow an observing site so broad and open as in flat country; and in the same way in large towns the same scrupulous care—even if it were possible to exercise it—to have the site far from buildings would not be so necessary as in country places where buildings are scarce, and, as it were, accidental. A little study of the general topography of a locality would in most cases soon enable one to judge of a suitable and representative spot for installing a freely-exposed thermometer.

The temperature as indicated by a freely-exposed thermometer I should call the temperature of the thermometer *due to the atmosphere*—using the word atmosphere in the literal Greek sense, to denote something more than the air alone; it would give a more liberal index of how cold or hot it is, from day to day and place to place, than the mere temperature of the air as registered by sheltered instruments. If the proposal comes to be adopted, and isothermal maps come to be eventually drawn as a result, a comparison between the two sets of isothermal charts as derived from the sheltered and exposed thermometer readings would be highly interesting and instructive.

In the above paper I have purposely failed to refer to the black and bright bulbs-in-vacuo as being irrelevant to the question at issue. These thermometers, by being deprived not only of wind, but even of air, simply afford a rough index of the comparative diathermancy of the air from day to day—that is to say, of the amount of radiant energy which succeeds at a given instant in escaping absorption before reaching the bottom of the air; they consequently tell us nothing of the heating effect upon exposed bodies of the transmitted radiation, which, as aforesaid, depends not only upon contact with air but above all upon the windiness of that air.

The fact of exposed thermometers being wetted by rain and snow need in no way be prejudicial to the object for which it is proposed to establish them. The thermometer, like any other object, will be affected by the temperature of the falling rain or snow, and this includes just what I want to get at. In a general way the drying of the bare thermometer bulb and tube after rain would be effected very rapidly in sunshine and wind; but even on occasions when the drying would be sluggish and liable to steal heat from the bulb of the thermometer after the fashion, in a smaller way, of a muslined wet-bulb, no theoretical difficulty need arise, since the condition of the thermometer would be the *natural* condition of all other exposed objects, and the *nature* of the surface of any object which is a factor, as we saw above, in determining the extent to which that surface may be heated or cooled by external agency, is itself altered when it becomes damp through rain.

The most serious difficulty attending the use of exposed thermometers in some countries would be their liability to be broken by hail. In the British Islands, however, hail is by far the rarest of all forms of precipitation (the real thunderstorm hail that is to say, as distinct from "graupel," which is very common, and, though often called hail, is really a form of snow); and I do not see why an exposed thermometer at 4 feet above the ground should suffer from hailstorms more than the grass-minimum or solar-vacuum instruments do.

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DISCUSSION.

Mr. D. W. HORNER said he congratulated the author of the paper on being sufficiently bold to attack the Stevenson screen. He thought the great difficulty in carrying out the project would be, that one would be obliged to sit beside the thermometers all day and watch them, or else have self-recording instruments to take the records. Readings from ordinary thermometers would be of little if any value for the purpose suggested.

Mr. F. J. BRODIE said that the writer of the paper did not suggest abolishing the screen, but using these thermometers in addition. He himself had long been under the impression that something of this kind should be done. Temperatures in the screen and those recorded by solar thermometers are not those experienced by plants or human beings exposed to the sun's rays. One would want to know the actual temperature experienced by objects exposed to the sun's rays. This was not recorded by a thermometer in a box or one *in vacuo*. He thought the suggestion in the paper to take these additional observations a very good one; it would be interesting to have observations taken at a selected number of stations. The comparison of the different temperatures in sun and shade would be of interest. It would of course be difficult to choose a proper situation.

Mr. W. MARRIOTT read a letter from the Hon. Rollo Russell, who stated that he had long held strongly that such readings should be taken. The temperature, *e.g.*, of a leaf on an extended branch is often very different from that of an enclosed thermometer.

Dr. H. R. MILL said a good deal of work had been done in the way of taking observations by thermometers exposed to the air. Mr. John Aitken showed twenty-five years ago, in a series of experiments in which Dr. Mill had assisted, that it was possible to expose thermometers with very small bulbs to the rays of the sun without raising the temperature of the instrument above that in the screen. The covering of the bulb, whether reflecting or absorbing, and the size of it, had everything to do with the temperature shown. Mr. J. Y. Buchanan had shown that the variations in the readings of an extremely sensitive thermometer in the free air varied so frequently and so rapidly that without a self-recording instrument the observations would be absolutely hopeless. This showed the uselessness of attempting to compare the observations of exposed thermometers read at fixed hours. He agreed with the author of the paper that observations of this kind would be most interesting, but did not see how the mechanical difficulties of getting absolutely similar thermometers could be overcome, and no good object would be served if the measurement of temperature were vitiated by unknown thermal peculiarities of the instruments.

Mr. C. J. P. CAVE said that he agreed with Dr. Mill, and doubted whether it would be possible to get any useful results. He had taken some records from platinum resistance thermometers in the open and also in a Stevenson screen. They differed a little in bright sunshine, but at night there was very little difference. The one in the screen did not respond so readily to changes of temperature. During the day temperature fluctuations were very rapid.

Mr. W. W. BRYANT said he was rather against making a series of observations of this haphazard kind, but thought one or two notes might be interesting. Regarding the paragraph in the paper "A sunny day with an air temperature as recorded on a Glaisher stand or in a Stevenson screen of, say, 55° only, is in a broader sense a hotter day than an overcast day with an air temperature as high as 65°, and from the point of view of the needs of vegetation is very effectually a hotter day," he wished to point out that a sunny day with an air temperature of 55° would occur in winter, whereas a day with an air tempera-

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ture of 65° when overcast could only occur in the summer, and therefore the rest of the sentence would become void of any meaning.

Mr. R. INWARDS remarked that Prof. Tyndall had said, in a lecture at the Royal Institution, that the proper way to take the temperature of the air was to hang a thermometer in the middle of a string stretched from one post to another in an open space, exposed to sun, wind, or rain.

The PRESIDENT said that he was sure the Fellows would wish to convey the thanks of the Society to Mr. Bonacina for his paper. Evidently very much depended upon what he might call the personal equation of the thermometer, and also on the exposure. He hardly thought it would be possible to get a sufficiently uniform exposure to make the observations very valuable.

Mr. L. C. W. BONACINA, in a note to the Secretary, said: "I venture to suggest that Mr. Bryant's criticising remarks are somewhat wide of the mark. Apart from the fact that in certain months, notably May and September, one is liable to get a cloudy day with a temperature of 65°, and a sunny day with 55° only, my contention was simply that *any* sunny day with 55° affords more heat in addition to light available for the growth of vegetation than any overcast day with 65°. In the depth of winter there might be a temperature of 55° on a fine day, but then, no *hot sunshine* is possible in December, however fine the weather may be."

MR. C. L. PRINCE'S OBSERVATIONS ON THE TEMPERATURE IN THE OPEN AIR AND IN THE SHADE.

[The late Mr. C. Leeson Prince for a number of years made a regular series of observations at Crowborough on the temperature in the open air and in the shade. As these have a great bearing on the subject dealt with in Mr. Bonacina's paper we reprint the following excerpt from Mr. Prince's book, *Observations upon the Topography and Climate on Crowborough Hill, Sussex.* Second edition. Lewes, 1898. Pages 22-27.—EDITORS.]

"So much difference is found to exist in the climatology of places situated not far distant from each other, that it may be as well to inquire what is meant by the term 'Climate,' as it affects the mental and physical condition of any community; and the following appear to be the more important influences, viz. the condition of atmosphere with respect to its pressure, temperature, rainfall, humidity, and prevalent winds; its general freedom from noxious exhalations; its transparency as it affects radiation from the earth's surface—the amount of radiation itself being dependent, in a great measure, upon the nature of the soil; lastly, there is its electrical condition, which is doubtless a very important element, but extremely difficult of detection, both as to its volume and specific character.

It will thus be seen what a field of inquiry lies open to those who seek to obtain all possible information with respect to the above-mentioned subjects, and how much care and patience are required for the several investigations.

In commencing a series of meteorological observations upon the summit of Crowborough Hill, the inquiry could not fail of being especially interesting, inasmuch as it would relate to the highest inhabited spot in this county, and also that no observations of a similar nature had ever been attempted in the South of England at so great an elevation above the sea.

During the first year of my residence I commenced observations of a similar kind to those which I had conducted for so many years at Uckfield. In the following year a considerable discussion arose, among our most eminent English meteorologists, respecting the particular form of thermometer-stand which

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should be employed for the reception of self-registering thermometers, but without any very satisfactory result. It was, however, thought desirable, upon the whole, to adopt a form of stand known as 'Stevenson's stand,' which is, I believe, the form of stand at present recognised and adopted by the Meteorological Societies of England and Scotland.

The endless varieties of opinion expressed upon this subject induced me to commence a series of observations from self-registering instruments placed upon an open stand, without any protection whatever, a representation of which is given in the accompanying illustration.



Self-Registering Instruments upon an Open Stand.

The thermometers were here exposed to every influence from radiation and wind. I attached additional interest to their indications, in the first place, because of their almost unique character; and secondly, because I had an impression that they would show, in a faithful manner, the temperature to which vegetation was actually exposed both by day and by night. In addition to the usual maximum and minimum thermometers, I also placed upon the stand another thermometer, having its bright bulb secured *in vacuo*, to register the heating power of the sun's rays.

With the exception of some observations made in Scotland in the years 1861-1862, and which are embodied in a paper by Alexander Buchan, Esq., 'On the Meteorological Conditions which determine the Profitable or Unprofitable Culture of Farm Crops in Scotland,' published in the *Quarterly Report of the Scottish Meteorological Society* for June 1862, I am not aware that any records of temperature, from exposed instruments, have been published. In the course of his paper, Mr. Buchan remarks: 'The distinguishing peculiarity of the observations depends on the threefold conditions under which the instruments were placed, viz. their bulbs not blackened, their height (four feet) from the ground, and their full exposure to sun and weather. Naked bulbs were preferred to blackened bulbs, inasmuch as observations made with unblackened bulbs furnish results more uniform, reliable, and comparable with each other than could otherwise be the case.' For information respecting local climatology, and its adaptation as a health resort, or for any particular agricultural requirements, I hold that observations as to temperature should be conducted with

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fully exposed instruments in preference to those placed in a 'Stevenson's stand,' or any other device for protecting them against the influence of any source of radiation. The comparative tables of mean highest temperature in the open air and in the shade respectively [Tables I. and II.], for eleven years, will show that the former gives a mean of 5°·6 in the three summer months above the latter, which constitutes a difference sufficient to decide whether or not certain cereal crops can be cultivated. There are several other points connected with the subsequent tables, which I trust will be of some interest and use both to the meteorologist and agriculturist, as exhibiting the variations in temperature indicated by the two methods of instrumental position.

TABLE I.—MEAN MAXIMUM TEMPERATURE IN THE OPEN AIR.

Month.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	Mean.
	°	°	°	°	°	°	°	°	°	°	°	°
January .	46·3	46·1	40·0	46·8	43·9	34·7	38·5	36·1	43·4	44·2	46·6	42·2
February .	45·1	39·2	45·0	48·9	46·5	42·7	48·9	42·2	48·0	48·5	47·6	45·7
March .	51·4	46·3	48·1	48·6	50·1	49·4	56·3	52·7	56·3	45·9	54·0	50·8
April . .	59·7	56·6	56·0	54·4	58·5	54·2	58·2	55·8	59·4	59·8	56·5	57·2
May . .	62·3	65·4	60·2	59·2	65·5	60·8	67·5	66·2	67·2	65·3	67·0	64·2
June . .	69·7	68·2	69·6	73·6	72·8	67·8	69·1	71·1	69·1	71·2	70·5	70·2
July . .	77·4	67·8	78·0	72·1	76·3	68·9	74·6	79·5	72·2	72·7	77·5	74·2
August .	70·1	73·1	75·8	72·0	73·6	70·8	75·2	71·0	72·1	75·2	81·8	73·7
September .	66·8	69·6	65·8	63·2	69·0	66·6	70·7	66·3	66·1	68·7	70·5	67·5
October .	58·8	54·8	58·7	58·0	60·0	58·7	55·5	53·7	58·8	58·7	58·1	57·6
November .	48·4	46·5	49·2	51·9	44·1	44·0	48·5	52·7	48·8	49·9	46·6	48·2
December .	36·7	40·7	46·6	44·7	37·6	38·1	47·4	43·3	44·3	42·9	43·1	42·3
Year . .	57·7	56·2	57·8	57·8	58·2	54·7	59·2	57·5	58·8	58·5	59·9	57·8

TABLE II.—MEAN MAXIMUM TEMPERATURE IN THE SHADE.

Month.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	Mean.
	°	°	°	°	°	°	°	°	°	°	°	°
January .	44·8	44·8	39·4	46·4	41·9	34·2	36·8	34·3	42·4	43·1	45·4	41·2
February .	43·2	37·0	42·9	46·5	44·2	40·6	46·6	40·5	45·2	45·9	45·3	43·4
March .	48·6	43·2	45·2	45·1	45·8	46·0	51·7	49·0	52·5	42·0	49·4	47·1
April . .	57·4	52·8	52·0	50·6	54·0	48·9	52·7	51·1	54·5	53·9	50·4	52·5
May . .	58·7	60·6	54·8	53·9	60·0	54·2	60·1	60·6	61·0	60·3	61·8	58·7
June . .	66·3	63·5	64·2	68·2	66·6	61·8	63·6	64·2	63·1	66·4	65·5	64·8
July . .	74·5	63·9	72·2	66·4	69·5	63·1	66·8	73·2	66·1	67·1	70·8	68·5
August .	67·0	67·7	71·0	66·7	67·5	65·2	69·5	65·2	66·1	69·9	75·3	68·2
September .	64·2	65·3	61·8	58·5	63·9	61·7	66·2	61·5	61·2	63·3	65·6	63·0
October .	56·5	52·0	56·3	54·5	56·1	55·3	52·7	49·7	55·3	55·2	54·4	54·3
November .	46·9	45·4	47·5	49·8	42·0	40·9	46·3	51·6	46·8	47·9	44·9	46·3
December .	35·4	39·4	45·2	43·4	36·0	36·9	45·0	42·1	43·0	42·0	42·2	41·0
Year . .	55·3	53·0	54·4	54·2	54·0	50·7	54·9	53·6	54·7	54·7	55·9	54·0

Both sets of instruments have been placed four feet above the ground, which, of course, renders their indications fairly comparable. It appears quite certain that, even then, fully exposed thermometers do not register so high a temperature as that to which vegetation is exposed, on account of the sun's rays being considerably deflected from the bulbs themselves; nevertheless they give a near approximation thereto, and, moreover, it is satisfactory to know that all kinds of crops are really subject to a higher temperature than the thermometers register. It should be duly considered that observations taken

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from instruments which are completely protected from the direct rays of the sun are not only absolutely useless, but positively misleading, when we know that during the important summer months they register perhaps a temperature of 10° lower than that which plants have been exposed to, and influenced by, during their period of growth and maturation.

The table which gives the mean highest temperature in the sun's rays will probably be the most valuable to the agriculturist, and is altogether superior to the results shown by reference to the table of mean temperature, which, alone, will not inform us whether a certain crop will, or will not, grow to perfection in any given locality. The mean daily highest temperature, and the mean monthly temperature, as shown by protected instruments, are wholly unable to indicate the actual summer temperature by which growing crops have been influenced. The true night temperature, to which most plants have been exposed, can only be ascertained by reference to the terrestrial radiation thermometer, placed upon the surface of short grass, and the exposed minimum thermometer, placed four feet above it.

It is, however, possible, if not probable, that the terrestrial radiation instrument may show a lower temperature than that to which growing crops have been exposed when they have attained the height of a foot, or more; but a *very* approximately true condition of night temperature could be ascertained by adopting the results of the mean of these two thermometers; indeed, I cannot suggest any better method of obtaining the information sought for.

A competent knowledge of the average *night* temperature of any locality is of far more importance in respect of the healthy condition both of animal and vegetable life than is generally supposed, and will often explain the reason, more particularly, why the latter flourish more freely in some situations than others, whatever care may have been taken in each instance."

Effects of a Storm on Barden Fell, Yorkshire.

Some striking illustrations of the erosive action of flood water during a storm are supplied in the *Proceedings of the Yorkshire Geological Society* for 1908 by Mr. A. Gilligan. The storm in question was that of June 3, 1908, which played much havoc in West Yorkshire, particularly in the neighbourhood of Barden Fell. This hill, which reaches a height of 1661 feet, is drained radially by a number of becks, which all run down steep scarp slopes of the Kinderscout grit. Mr. Gilligan describes the effects of the sudden flow of water down these channels, as well as the excavation of entirely new channels where none had existed previous to the storm. In one of these the solid grit had been removed in many places to a depth of 20 feet, while the greatest width was 12 feet. The deepest holes were always found succeeding a place where the water had been imprisoned in a narrow channel. In the case of smaller channels branching from the larger ones it was found that the cutting commenced quite suddenly, owing no doubt to the cutting back of the waterfalls formed by the rapid deepening of the main channels. In Barden beck, the main outlet for the flood, the water-level rose at least 10 feet, while thousands of tons of material were carried into the two reservoirs connected with it. On Embsay Fell several mills were quite wrecked. —*Geographical Journal*, July 1909.

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DINNER OF THE ROYAL METEOROLOGICAL SOCIETY.

The Annual Dinner of the Society was held at the Trocadero Restaurant, Piccadilly, on Tuesday evening, June 15, 1909.

Mr. HENRY MELLISH, the President, was in the chair, and the company included the following Fellows and guests :—

Mr. F. CAMPBELL BAYARD.
Mr. RICHARD BENTLEY.
Mr. F. J. BRODIE.
Capt. F. G. P. BUTLER.
Capt. W. F. CABORNE, C.B.
Mr. C. J. P. CAVE.
Sir WILLIAM CHURCH, Bt.
Mr. J. E. CLARK.
Capt. M. H. CLARKE.
Mr. R. COOKE.
Mr. R. CROSS.
Major H. A. CUMMINS.
Mr. T. S. DYMOND.
Mr. F. B. EDMONDS.
Mr. H. N. FFARINGTON.
Mr. L. R. W. FORREST.
Sir DAVID GILL, K.C.B., F.R.S.
Mr. E. GOLD.
Dr. GORDON.
Rev. Dr. J. GOW.
Mr. W. V. GRAHAM.
Mr. N. HOLDEN.
Mr. R. INWARDS.
Mr. A. P. JENKIN.
Mr. B. LAILEY.
Mr. BALDWIN LATHAM.
Mr. G. B. LATHAM.
Mr. R. G. K. LEMPFERT.
Capt. W. G. LINGHAM.
Dr. W. J. S. LOCKYER.
Mr. A. MALLOCK, F.R.S.
Mr. S. S. MARKHAM.
Mr. W. E. MARKHAM.
Mr. W. MARRIOTT.
Mr. W. J. MARRIOTT.
Dr. H. R. MILL.
Mr. H. W. MONCKTON.
Mr. R. MOND.
Mr. P. P. PENNANT.
Colonel H. E. RAWSON, C.B.
Mr. C. SALTER.
Dr. R. H. SCOTT, F.R.S.
Mr. W. SEDGWICK.
Dr. W. N. SHAW, F.R.S.
Mr. C. H. THOMPSON.
Dr. J. H. T. TUDSBERY.
Mr. S. G. WARNER.
Dr. C. THEODORE WILLIAMS.
Representatives of
The Daily Telegraph.
The Morning Post.
The Times.

THE PRESIDENT, in proposing the toast of "The King," said that as we see how hard His Majesty the King works we realise more what a valuable asset he is to the British Empire.

"God Save the King."

THE PRESIDENT, in proposing the toast of "Her Majesty the Queen, the Prince of Wales, the Princess of Wales, and all the other members of the Royal Family," said that the health of the Queen is always welcomed in every assembly of Englishmen for her devotion to her subjects. His Royal Highness is the Patron of this Society, and we see how hard he works to qualify himself at some future time to take the place of his illustrious Father. And the other members of the Royal Family, we know, are always ready to forward the aims of our country.

"God Bless the Prince of Wales."

GLEE—"To a Zephyr."

Dr. H. R. MILL said—It is a momentous thing to propose the toast of "Kindred Institutions," for they are many. We hold as kindred all those institutions which are devoted to the study of the air, and the surface of the globe which the air enclasps, and even those regions of space which lie beyond the air. The

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toast, in fact, is all-embracing, for there is no one here who is not connected with one or more kindred societies. It is the habit of members of such societies to meet together in groups for the discussion of the special subjects of their own studies, and these meetings involve criticism, contradiction, and retort, and in some cases friction, which makes the wheels of progress bite, generates heat, and may give rise to irritation. It is for this reason, I suppose, that these societies are given to another expression of the gregarious instinct in meeting occasionally for social purposes, when the disputants of the scientific meeting exchange the heat of argument for the warmth of convivial intercourse. Here, where our study is meteorology, the weather as a subject of reference ought perhaps to be *tabu*; but on such an occasion the common topic of conversation may be admitted if handled with imagination rather than with science. There seems to be a feeling abroad that we are responsible for the weather, but I do not know where the burden lies—the responsibility for rain is sometimes placed upon me; much as I would rather live in the sunshine. In a pleasant dream I could fancy that for the last fortnight I have been in possession of the regulator of the weather purloined, say, from No. 66·5 Victoria Street (that I think is the true mean between 63 and 70), for I have been in the western islands of Scotland enjoying constant sunshine and light winds never carrying a drop of rain, for all the world as if I were travelling in my own private anticyclone. Were it within our power to have the command of such a conveyance, no doubt our pleasure in it would be largely spoilt by the prospect of the prodigious duty to be imposed by some future Chancellor of the Exchequer upon so great a luxury. While the anticyclone overspread me, you in the south were under the influence of a procession of little cyclones which caused their rain to fall on 63 and on 70 Victoria Street alike, and not even forgetting 62 Camden Square. Perhaps they were the attendant sprites heralding the progress across the Atlantic of the great meteorological swell which should have broken in oratory upon us to-night in the person of Professor Willis Moore, Chief of the U.S. Weather Bureau, the greatest of our most kindred institutions. But the progress has been retarded, and we are the poorer, as our hoped-for guest is still upon the sea. Or it may be that the withdrawal of the anticyclone to the north-west left the south-east the prey to evil influences which its presence would have held in check, as we are told by early writers that comets are the souls of just men whose appearance in the sky presages wars and woes in the world from which their bodily presence had kept it free. We are fortunate this evening in the presence of an astronomical wanderer whose transference from the Southern to the Northern Hemisphere has enriched us and left no malign influence on the land he formerly enlightened, where we see peace and the promise of union and prosperity—Sir David Gill, formerly Astronomer-Royal at the Cape. Not he alone, but many other guests represent kindred institutions from which we of this Society derive the very greatest aid in our researches, and to which we hope in return to be able to supply facts of our science no less helpful to them. It would be ponderous to give a list of them all, and pedantic to attempt a classification of their various activities. Some are devoted to the furtherance of pure science, others to the applications of science to the needs of humanity. To all of them we owe a debt, and from each of them we receive a benefit. In proposing the toast of "Kindred Institutions," I associate with it the names of Sir David Gill, President of the Royal Astronomical Society, formerly President of the British Association, that great compendium of all kindred societies; and of Sir William Church, President of the Royal Society of Medicine, a union of kindred societies which has set a fine example of mutual co-operation in the advancement of knowledge.

Sir DAVID GILL said—Mr. Chairman and gentlemen, if ever I was placed in a difficult position, you behold me now. I have been asked to reply to

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a most comprehensive toast, that of "Kindred Societies," and I looked forward for help with hope to the great meteorological authority who has been delayed by his beloved cyclones, and who will reach this country after our pleasant dinner is over. I feel in a difficulty when I come before you, as I have always been a great sinner in the past in matters meteorological. In the Colonies it seems to be thought that the duties of an astronomer are to make meteorological predictions. I explained once to Lord Milner why the Cape Observatory did not make predictions, because all our winds were from North-west or South-east, and we had only the sea in these two directions. But he said, "I know better than that. That is not the reason you do not make meteorological predictions; it is because you are a Scotchman." I own this. I used to receive frequently a telegram something like this: "We are going to have a picnic. What is your prediction of the weather for next Tuesday?" or "We are going to have a public meeting. On what day next week will the weather be most favourable?" I would explain to the first that my kingdom began at the moon and extended outwards, and to the second that I never prophesied unless I knew, and I didn't know. Thus, from a meteorological point of view, I was always considered a very poor creature indeed—which is perfectly true. While here, let me do penance and confess that astronomers owe much to the meteorologist. The Americans have shown us the immense importance of selecting proper sites for astronomical observatories — sites where the meteorological conditions in the way of clear skies and steady definition are to be found, and they have proved the surpassing advantages of such sites by the splendid work done on Mount Hamilton, Mount Wilson, and elsewhere. Well, gentlemen, I think I have made good my unworthiness, my failures, and have shown how unworthy the Society which I represent is to be regarded as one of those "Kindred Societies," except in this way, that every day and every year which passes teaches us more and more how closely the sciences are linked together. The astronomer, for example, has had to borrow from the physicist and the chemist for the foundation of astronomical spectroscopy; although, if time were available, I think I could show you that the astronomer will probably amply repay the debt. And I think I have shown how well the astronomer will do to take the meteorologist into his counsel before he selects the site of his observatory. Let me now express to you on behalf of the Astronomical Society our sympathy with you in your great work; and I recognise that in meteorology there is this great peculiarity, viz. that while meteorological observations are of themselves perhaps in their primitive forms the easiest to make, you have in the highest flights of meteorology yet to find the meteorological Newton, and he will have to tackle a problem so enormously complicated that the work of Newton or Adams is child's play compared to that which he will have to face. Yet Dr. Shaw tells me that when any special problem in meteorology has to be tackled, the investigator who sets about it invariably finds that although tons of books of meteorological observations exist he is generally pulled up for want of data. There is therefore in meteorology the amplest field yet for the earnest, humble observer, and for the most comprehensive genius. I thank you for the kind reference you have made to myself, and I thank you on behalf of my Society and the Kindred Societies for the kind manner in which you have received the toast.

Sir WILLIAM CHURCH also replied. He said—Mr. Chairman and gentlemen, it was only as Dr. Mill rose to propose this toast that he informed me of his intention to associate my name with it, and the effect upon me is that of a cyclone. I feel quite unprepared to thank the Society properly for paying this compliment to medicine. I think it is probably known to you all that medicine shares with your Society an interest in many subjects. We see in the public press about light cures, and no doubt there is a good deal in it.

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For many years medicine has recognised this, and has depended upon your Society for the solution of the sunshine problem. It may interest you to know that within the last few days the Balneological and Climatological Society has come within the folds of the Society which I represent, and is now a section of the Royal Society of Medicine. I might also venture to say that meteorology is of interest to most of those who practise medicine. As a rather convenient cloak to hide from our patient that we have exhausted all other means, we sometimes recommend a change of air, and we have to bear in mind his temperament and his predilection for certain spots. I thank you most heartily for having associated the Royal Society of Medicine with these institutions, and feel very highly the compliment of being asked to reply to the toast of the "Kindred Institutions."

MADRIGAL—"This pleasant month of May."

The Rev. Dr. J. Gow, in proposing the toast of the "Royal Meteorological Society," said (in brief)—Mr. Chairman and gentlemen, I have the honour to propose to you a toast to "The Royal Meteorological Society." I do not know why I was selected for the honour, but the Royal Meteorological Society is one of the schools of the prophets, and I happen to belong to another. I must be careful what I say, as I see that these toasts are many, and there is a Greek poet, who, describing the course of events after a dinner, said that the first cup is for health, the second for pleasure, the third for sleep, and then honest people go home, the fourth is for a quarrel, and the fifth is for a black eye. After so many cups I suppose you do not all feel affectionate, and I must take care to say nothing which is uncomplimentary. The Royal Meteorological Society seems to me to be the most educational Society, because it proposes to itself to reform the staple of English conversation. Hitherto we have been accustomed to say that it was "a very fine day," and the interlocutor would answer, "Yes, John, it is." We are now to say that the thermometer is 79°·5 in the shade, or something of that sort; and we are not to say that the English climate is changing, and this is the worst summer ever known, but that the English climate goes in cycles, and this is the same weather as we experienced in 1865. The Royal Meteorological Society is also that which has the greatest future before it. The time is coming when the English fleet will be in the air, and the Admiralty will be entirely recruited from the ranks of this Society. A large part of its work is no doubt done by the Meteorological Office, over which Dr. Shaw presides, but there is always in England great scope for an amateur. Though in so vast a subject as meteorology the amateur is at a disadvantage because he cannot collect statistics, still the ideas that make for progress in England generally come from some gifted amateur, and this Society will, I hope, produce the gifted amateur. Most of you know more about the subject than I do, but I presume that I am appealing to a friendly audience when I say that the Royal Meteorological Society has a great work before it. But my interest in the subject has always been very keen, and I have lectured on weather forecasts, partly those in which my interest was first aroused by Dr. R. H. Scott's book, but partly also the signs of the weather as given in Aratus, Virgil, and other writers in pre-scientific days. I have to couple with this toast the name of your President, Mr. Mellish, with whom also I have a little connection, for I lived in Nottingham for a good many years. I ask you to drink with the greatest enthusiasm to the President, and success to the "Royal Meteorological Society."

The PRESIDENT, in responding, said—Before replying to the toast I should like to take the opportunity of mentioning the disappointment of not having Professor Moore and other foreign delegates with us. We had hoped that some of them would have been in England a short time before their meeting, and so have been able to attend our dinner this evening. Another disappointment

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was the absence of Sir Daniel Morris. Then also we have been disappointed in Dr. Warren, the Vice-Chancellor of Oxford, but the Imperial Press Congress has gone down to be entertained at Oxford. Mr. Cyril Jackson, the chairman of the Educational Committee of the London County Council, Dr. Spencer of University College, and the President of the Aeronautical Society have also failed us. Now, gentlemen, I have, on behalf of the Society, to thank Dr. Gow for proposing this toast and for the speech in which he has done so. Though this Society is nearly sixty years old, it has not been the custom to hold an Annual Dinner until it was started by Dr. Mill three years ago. The position of the Society is, I am glad to say, a very satisfactory one, thanks to the energy which Dr. Mill threw into the work during the period when he was President, and to his having brought in a considerable number of new Fellows, although we want a good many more. It has been pointed out that in some sciences the amateur can work for himself in his own laboratory, and it is only when he wants to publish his researches that a Society's aid is necessary, but in meteorology he has to depend upon the observations of others. Observations have accumulated in large numbers, and what is most required now is working up the results, though the continuation of the observations must not be neglected. One of the largest blanks on our meteorological charts is in the Antarctic region; and speaking of this brings to my mind the return of a Fellow of this Society, Mr. E. H. Shackleton, who, we feel, has done good work in the cause of meteorology, and whose researches we hope in due course will be brought before the Society. During the last few years there have been a good number of expeditions to this part of the world, the results of which are now in course of publication, and we have coming before the Society to-morrow a research undertaken by Mr. Mossman dealing with the South Polar regions. Co-operation is necessary not only between individuals, but also between institutions both in this and other countries, and our relations with the Meteorological Office remain, as they have always been, most cordial. It is only during recent years that serious attempts have been made to investigate the upper air, and by means of this international co-operation a considerable amount of data is now being collected. Dr. Gow has referred to the navigation of the upper air, and we hope to get help from people who carry out this work. A great deal of work still remains to be done in the climatology of this country. In one item, that of rainfall, the work has been fully organised for some years. This was started by Mr. Symons, and is now being carried on by Dr. Mill. Another important item in applied meteorology is its connection with agriculture, which presents many complicated problems, which the Society has endeavoured to elucidate. We have collected observations of phenology, and we have also for some years sent an exhibit to the Royal Agricultural Society's Show, and we are sending one to Gloucester next week. During recent years we have tried to make meteorology popular by the lectures given by Mr. Marriott, and also in schools, and though there is considerable difficulty in fitting new subjects into the curriculum, we hope by degrees that more knowledge of meteorology may be brought before the rising generation. We pride ourselves on having got at our headquarters an excellent library on meteorology, and we take a good deal of trouble to see that the library is properly organised.

I think perhaps that I have shown that there is plenty of work still to be done, and I will conclude by thanking Dr. Gow for proposing this toast.

PART SONG—"Haste ye, Soft Gales."

Mr. RICHARD BENTLEY, in proposing the toast of "The Visitors," said—Mr. Chairman and gentlemen, the pleasant office next devolves upon me of rising to express, on behalf of the President, Council, and Fellows of the Society, the gratification which the presence of many guests, eminent alike in science and scholarship, and many of whom have come from far-distant parts, has

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afforded us this evening. The fascination of the uncertainties and still unsolved mysteries attendant on meteorology has from the earliest days arrested the attention of mankind—first, perhaps, of the agriculturist, whose crops largely depended upon the vicissitudes of the seasons; then of the mariner, who in days before the lodestone or compass groped his way anxiously along the shore with one eye on the coast-line and one upon the portents of the sky; next of the physician in quest of health resorts for the fragile or sickly; then of the engineer who safeguards the water-supply of our great towns and huger cities; and more recently of the military student who is investigating the wind currents in search of a future highway aloft. Unlike those of the Army Council, our recruits are enlisted for perpetual service. The tiller of the fields in Virgil's time has his successor in the scientific farmer of to-day who pays his shilling in harvest time and has his weather forecast direct from the Meteorological Office; the venturous sailor of the time of Columbus is now represented by the cautious captain of some Mail liner in the dangerous typhoon-swept seas of the Far East navigating with an eye closely kept upon his barometer; and if the discoverers of Bath or Tunbridge Wells are no more, we have still their successors among us equally alert to find fresh health resorts for the suffering. Dr. Mill has just demonstrated how widely embracing are the limits of meteorology, and it is no doubt to the ever-continuing and greatly increasing interest felt in it that we are fortunate in having the presence, both on this and on previous similar occasions, of so many friends and guests who take an interest in our work. The headquarters of the Society, as you all know, are at Westminster. The attendances, however, at many of our monthly gatherings are so large that we could not find the accommodation necessary under our own roof, and we are helped out of this dilemma by the courtesy of our neighbours at the Institution of Civil Engineers. I think I am correct in saying that the office of President of that Institution and also of the Meteorological Society was once filled at the same time by Mr. Robert Stephenson, and since that epoch the privilege has been hospitably accorded to us, enabling us to hold our most important gatherings within the walls of the Institution. We are glad to have with us this evening among other distinguished guests the Secretary of the Institution of Civil Engineers, and I will ask your permission to couple, therefore, with the toast of "The Visitors" the name of Dr. Tudsbery.

Dr. J. H. T. TUDSBERY, in responding to the toast, said—Mr. President, Mr. Bentley, and Fellows of the Society, I rise to obey the Chairman's call to answer for the many distinguished visitors, and to apologise—so far as a visitor may do—for the absence of others who have been prevented from attending. Quite apart from the exceptional advantages of observing that the science of meteorology is not incompatible with the enjoyment of the good things of life, we have heard from Dr. Mill what a beneficent influence these entertainments have in dissipating the cyclonic disturbances engendered by scientific discussions. We have heard from Sir David Gill of the indebtedness of scientific men to meteorology, and we have heard from Mr. Bentley, the proposer of this toast, that there are others equally interested in your work and your researches, whether it be the agriculturist, or the mariner who depends upon the winds, or the humble passenger who depends upon the calms. Your invitation would have been liberal indeed to include representatives of all classes of persons who take a real interest in your work. It is the glory of science that its discoveries and achievements are not directed to the personal interests of individuals, but are directed to a much wider issue, that of benefiting mankind. It is sometimes a curse of scientific societies when their work and labour are appraised by people in accordance with the benefits individuals derive from them. From such a sentiment this Society is happily free. We are extremely glad that you should ask us here to-night, because it shows that

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you recognise our appreciation of the single-mindedness of your work, and we thank you for permitting us to be present, that we may share in this small degree in the great work which you are carrying out in so public-spirited a manner.

GLEE—"When Evening's Twilight."

Dr. W. N. SHAW said—I beg to propose the health of the Chairman, and this I do with great pleasure because of the opportunity it gives me to refer to something already quoted from me. There are Meteorological Societies in Germany, France, and other countries, but the Royal Meteorological Society is the only one which has a monthly meeting. In this country more than in any any other are we prolific in amateurism. While it would be idle for me to justify this in any elaborate statement, I will only refer to the work of Mr. Dines and Mr. Cave, who are amateurs. Sir David Gill has quoted me to say that every worker in meteorology bewails the lack of data, but he went on to say that meteorological observations are either so easy that they could be taken by any one, or that if special research were being made, no data existed for the inquiry and fresh observations had to be started. I look to Mr. Mellish, with the assistance of a devoted body of officers, to demonstrate that there are a great number of problems which can be satisfactorily dealt with by an amateur. I now ask you to drink to the health of the Chairman.

The PRESIDENT briefly expressed his thanks, after which the proceedings terminated.

The music was under the direction of Mr. H. Schartau.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 19, 1909.

Ordinary Meeting.

HENRY MELLISH, Esq., F.R.G.S., President, in the Chair.

JAMES CAMPBELL CARSON, 8 Wellington Place, Belfast;
Capt. RICHARD POTTS CRAVEN, Mossley Hill, Liverpool;
Lieut. EDWARD JAMES HEADLAM, R.I.M., F.R.G.S., Bombay, India; and
ARTHUR OLDHAM LEES, F.R.G.S., 42 South Grove, Highgate,
were balloted for and elected Fellows of the Society.

The following communications were read:—

1. "THE ANTICYCLONIC BELT OF THE NORTHERN HEMISPHERE." By Colonel H. E. RAWSON, C.B., R.E., F.R.Met.Soc. (p. 233).

2. "ERRORS OF ESTIMATION IN THERMOMETRIC OBSERVATIONS." By ALBERT WALTER, F.R.A.S. (p. 249).

June 16, 1909.

Ordinary Meeting.

HENRY MELLISH, Esq., F.R.G.S., President, in the Chair.

EDWARD C. BARTON, Brisbane, Queensland;
CECIL BROADBENT, Royal Societies Club, St. James' St., S.W.; and
BANKIM CHANDRA SEN, Chittagong, Bengal, India,
were balloted for and elected Fellows of the Society.

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THE PRESIDENT said the Council had thought it an opportune moment to send their congratulations to Mr. E. H. Shackleton, who, as they knew, was one of the Fellows of the Society, on his achievements at the South Pole. He regretted to have to mention the loss of one of their oldest Honorary Members, Dr. Neumayer, the head of the Hamburg Institute for many years. Dr. Neumayer was elected an Honorary Member in 1874. The Council had sent a message of condolence to his relatives.

The following communications were read :—

1. "THE INTERDIURNAL VARIABILITY OF TEMPERATURE IN ANTARCTIC AND SUB-ANTARCTIC REGIONS." By R. C. MOSSMAN, F.R.S.E. (p. 259).

2. "NOTE ON THE TESTING OF REGISTERING BALLOON APPARATUS AT LOW TEMPERATURES." By Dr. W. SCHMIDT and E. GOLD, M.A., F.R.Met.Soc. (p. 275).

3. "A PLEA FOR THE USE OF FREELY-EXPOSED THERMOMETERS IN ADDITION TO SHELTERED ONES." By L. C. W. BONACINA, F.R.Met.Soc. (p. 281).

CORRESPONDENCE AND NOTES.

The Meteorological Club.

The Members of the Council of the Royal Meteorological Society have for many years been accustomed to dine together before the evening Meetings of the Society. Some time ago it was thought that other Fellows might like to join the Council in these social gatherings, and so in 1907 "The Meteorological Club" was formed. The object of the Club is to promote the usefulness of the Royal Meteorological Society, by affording opportunities to Fellows for dining together informally before the Meetings, and encouraging conversation on subjects of meteorological interest.

The membership is limited to Fellows of the Royal Meteorological Society. The Officers and Council of the Society are *ex officio* Members of the Club. New Members may be proposed by any Member, and the election takes place at the next following Dinner.



Any Member may introduce one guest to any Dinner.

Each Member pays an Annual Subscription of 2s. 6d. to defray the cost of printing and other expenses.

The Dinners take place in the Westminster Palace Hotel, Victoria Street, at 6·30 p.m., before the evening Meetings of the Society. The charge for the Dinner, without wine, is 3s.

Dr. H. R. Mill during his Presidency presented the Club with a cigarette case, in the form of a silver Raingauge, as shown in the accompanying illustration.

Fellows wishing to join the Club are requested to communicate with the Honorary Secretary, Mr. W. Marriott, 70 Victoria Street, Westminster, S.W.

Cricket Match on the Ice at Ely during the Great Frost of February 1855.

Having had some correspondence with Mr. Harold Archer of Ely with reference to the dates of prolonged frosts in London, given in the recently

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published second edition of the little book, *Some Facts about the Weather*, he subsequently supplied me with the following interesting particulars, which many others will no doubt like to read. WM. MARRIOTT.

1853.

February 10.—Frost set in at Lynn.
" 17.—Snow fell at King's Lynn 2 feet deep on the level ground.
" 19.—A man was frozen to death in the snow at Babingley, near King's Lynn.
" 22.—A sudden thaw took place, causing, with the action of the tide, the water in Lynn Harbour to overflow on to the Quays, depositing large blocks of ice on to the surface of such Quays.
" 24.—Frost set in again.
" 26.—A large sea bird (Gannet) fell to the ground at King's Lynn exhausted with cold.

1854.

January 7.—Heavy fall of snow in the King's Lynn district, delaying the service of the railway trains.
" 21.—The tidal Wisbeach River was frozen up with ice 10 inches thick in some places.

1855.

January 14.—Severe frost set in at Cambridge.
" 17.—Snow blocked East Anglian Railway, and a passage had to be cut between Wendling and Dunham (in Norfolk) to release trains embedded in it.
February 12.—Cricket match on the Dock at Ely. Mr. Dabito (of Ashley's) side scored 160 in two innings; Mr. Hill's eleven (Ely) 154 in two innings with 3 wickets to fall.
" 17.—King's Lynn Harbour frozen up. Some ships remained frozen up for twelve weeks.
" 24.—Tidal river Ouse at Lynn frozen up, so that the sailors walked along the ice to get to their ships.
March 3.—Gas-pipes at Lynn were frozen up. Then a thaw set in.
" 10.—24 degrees of frost registered at Cambridge.
" 11.—25½ degrees of frost registered at Cambridge.
" 16.—Severe frost registered at Cambridge.

These notes confirm your statement that the long frost was in 1855, but you will observe that in that year the frost continued for a much longer date in the Fen country than it did in London. Ships were frozen up in Lynn Harbour for twelve weeks in succession.

During that same frost it was commonly reported here that a bullock had been roasted whole on the ice on the river Thames near the Temple Gardens.

With regard to the cricket match, the wickets were stuck into beds of clay about 4 inches in depth that had been soaked in salt and water. On the crease a deep cut had been made in the surface of the ice about 6 inches deep, and the bowler used to skate slowly up to this cut, put his skate into it to stop himself from going farther, and then deliver the ball overhand fashion against the batsman.

A deep cut was made in the surface of the ice where the batsman stood. His right foot, or rather the skate upon it, was shoved down into the crack to steady him as he struck at the ball that was bowled at his wickets. Sometimes the batsmen struck so hard at the ball in passing that the swing of their bodies brought them down on to the ice.

In making the runs the batsmen developed far too much speed, and used to

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dash into some of those behind the wickets (notably the unfortunate wicket-keeper), and clutched them so wildly that in many instances both fell together on the ice.

When the ball was hit by the batsman off the ice on to an adjoining field, those who were fielding had to go after the ball as best they could with their feet encased in their skates.

I trust that these notes may be of some service to yourself and your Society. HAROLD ARCHER.

P.S.—My notes as to facts and dates have been taken from the files of the *Cambridge Chronicle* and the *Lynn Advertiser*. The particulars about the cricket match are supplied from my own recollections. I observed from the above-mentioned newspaper files that Turkey Smart (of Welney), and R. Register (of Southery), and "Gutta Percha" See (of Welney), and T. Porter (of Southery) were the leading competitors in the skating matches of that season. Smart and Register afterwards skated a mile above Ely high bridge, with a strong South-west wind behind them, in something under two minutes, a pace equal to something over 45 miles an hour.

Observations of Sheet Lightning at Epsom, August 8, 1909.

After a fine and hot day with a shade maximum of 78°, sheet lightning was first seen here in the south at 9.30 p.m. The night was fine and starlight, the only cloud being an irregular layer of stratus to the south and south-east, visible only when lit up by the flashes. The radiant point of the flashes, starting at south, worked slowly round to south-east. The more brilliant of the flashes shot up beyond the zenith from the horizon.

The following table shows the number of flashes of sheet lightning, at intervals of five minutes, from 10 p.m. to 12 p.m.:—

10 p.m. to 11 p.m.		11 p.m. to 12 p.m.	
10 to 10.5	16 flashes	11 to 11.5	14 flashes
10.5 to 10.10	14 ,,	11.5 to 11.10	12 ,,
10.10 to 10.15	20 ,,	11.10 to 11.15	10 ,,
10.15 to 10.20	31 ,,	11.15 to 11.20	21 ,,
10.20 to 10.25	15 ,,	11.20 to 11.25	8 ,,
10.25 to 10.30	26 ,,	11.25 to 11.30	5 ,,
10.30 to 10.35	12 ,,	11.30 to 11.35	3 ,,
10.35 to 10.40	20 ,,	11.35 to 11.40	1 ,,
10.40 to 10.45	30 ,,	11.40 to 11.45	0 ,,
10.45 to 10.50	18 ,,	11.45 to 11.50	1 ,,
10.50 to 10.55	27 ,,	11.50 to 11.55	0 ,,
10.55 to 11	22 ,,	11.55 to 12	0 ,,
1 hour	251 flashes	1 hour	75 flashes

The following table shows the number of observations on the colour of the flashes at intervals of fifteen minutes, from 10 p.m. to 12 p.m. :—

10 p.m. to 11 p.m.	White.	Yellow.	Red.	11 p.m. to 12 p.m.	White.	Yellow.	Red.
10 to 10.15	25	10	0	11 to 11.15	17	11	3
10.15 to 10.30	40	11	2	11.15 to 11.30	4	28	2
10.30 to 10.45	37	14	3	11.30 to 11.45	0	0	4
10.45 to 11	48	10	0	11.45 to 12	0	0	1
1 hour	150	45	5	1 hour	21	39	10

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The total number of flashes seen in the two hours, 10 to 12 p.m., was 326. The total number of colour observations during this period was 270, viz.: white, 171; yellow, 84; and red, 15.—SPENCER C. RUSSELL, Epsom, August 9, 1909.

[The lightning referred to by Mr. Russell was seen by other observers in London and the south-east of England. It was connected with violent thunderstorms which were taking place in the north of France. The lightning was consequently seen for a distance of over 100 miles from the actual thunderstorm with which it was associated.

Mr. Marriott in his paper[1] on the "Thunderstorms of May 18 and 19, 1888," gave two instances of lightning having been observed at a distance of more than 100 miles from the thunderstorm. Mr. Symons, in the discussion, also said that "he remembered one instance (April 12, 1857), which fully bore out the great distance from the thunderstorm area at which lightning could be seen. The thunderstorm was in progress in the English Channel near Cape Gris Nez, and the lightning was seen as far north as Nottingham. It therefore appeared to be perfectly possible to see the reflection of lightning at a distance of 175 miles."—EDITORS.]

Balloon Ascent in a Snow-storm.

At the Meeting of the Royal Meteorological Society on November 18, 1908, the Hon. C. S. Rolls referred to certain electrical phenomena observed by aeronauts in balloon ascents in winter time. He has recently called our attention to an article in *l'Aérophile* in which M. E. Carton gives an account of a balloon ascent made from Paris in a hail and snow storm.

The following is the translation of this interesting article :—

"In the course of balloon ascents I have oftentimes had the opportunity of making some curious meteorological observations. But it has never before happened to me to observe the phenomena occasioned by the sudden appearance of a squall of snow and hail as I did on April 19, 1908, in the course of an ascent on board the *Araine* (450 m. [15,892 cub. ft.]) in company with M. Louis Méan, leaving the Bois de Boulogne at 3.55 p.m. The day was marked by showers of hail and intermittent snow, with rather low temperature—such as is generally called 'showery.' At the time of departure the temperature was 8°·5 C. [47°·3 F.], and the barometric pressure 756 mm. [29·76 ins.].

The voyage over the Bois de Boulogne and most of Paris was accomplished at a mean altitude of 350 m. [1150 ft.] in an ordinary manner; easy equilibrium without throwing out of ballast, slightly decreasing temperature. The clouds which surrounded us were of a very diverse character. Light stratus stretched to the horizon on the south, while the north, and particularly the north-west, the direction from whence the wind came, was highly laden with dense nimbus, which was very dark, and of great height. In observing these we easily noticed that they were gathering; the sun, which had scarcely been visible to us since our departure, now disappeared; and at 4.10, after a slight descent to 250 m. [820 ft.], followed by a throwing out of 4 to 5 kilos of ballast, we steadied ourselves about 400 m. [1310 ft.], enveloped on all sides by dense clouds. We made another slight and steady ascent to 600 m. [1970 ft.] after having again thrown out several kilos of ballast.

We had crossed a great part of Paris, recognising below us the gas-works in the Avenue de Choisy, when, without our being raised, the clouds hid the earth from us. (The barometer still indicated 600 m. [1970 ft.], 702 mm. [27·64 ins.]).

At 4.20 the first flakes of snow made their appearance all round us, and almost at the same instant a terrible noise caused by the fall of hailstones,

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. 14, pp. 296-299, 1888.

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which we found were of large size, 8 to 10 mm. [0·3 to 0·4 ins.] in diameter, made itself heard, while the balloon was violently tossed about, which caused a marked swinging of the car. Quickly a large sack of ballast of 20 kilos [44 lbs.] was prepared, while I observed the barometer, in readiness for a hurried descent. The hand instead of indicating a downward movement, made just the opposite; the hail still fell; my companion having also a barometer confirmed this same upward movement, which excluded the impression that my instrument had got out of order. We soon reached 800, 1000, and 1500 m. [2620, 3280, and 4920 ft.] of altitude, and in 10 minutes we were drawn up almost vertically to 1900 m. [6230 ft.], without throwing out a gramme of ballast, while the hailstones struck the envelope of our balloon with great noise.

At 4.35 the hail ceased and intense cracklings were heard around us. I at once accounted for these as being due to electrical discharges on the anchor which was hung at one side of our car, for I had had opportunity before of making observations of a similar kind. However, in estimating that this electrical crackling had manifested itself already for at least 5 minutes, during the fall of hail, this showed that the total and continuous duration of this phenomenon must have been about 20 minutes. The cracklings were sometimes so strong as to cause the vibration of the basket work of the car towards the part where the anchor was.

At 4.45 we were in full descent; two sacks of ballast of 22 kilos [49 lbs.] were thrown out in a few minutes, but still the descent grew faster. At 4.48 the last sack was thrown out, making with the two preceding ones about 65 kgr. [143 lbs.], and at 400 m. [1310 ft.] we saw, on coming through the clouds, a wood beneath us. The covering of the balloon bent beneath the gusts of the wind. Two minutes later we were on the ground; or rather we were thrown against the trees, the snow and wind being furious.

After having touched the top of the branches, we succeeded in dragging, without danger, to a neighbouring glade, and we, fortunately, finished our journey in the wood of Lagrange, at Yerres.

In the opinion of the persons present the squall was most violent, and was accompanied by a fall of snow sufficient to completely cover the ground. On the balloon, during the descent, there was a crust of frozen snow 7 or 8 centimetres [2 or 3 inches] thick. This was partly detached when the balloon came to rest.

The minimum temperature was observed at 1400 m. [4600 ft.]. It was from − 3° C. [26°·6 F.], while it was only − 2° C. [28°·4 F.] at 1900 m. [6230 ft.]. Several minutes after the descent, we observed on the ground: thermometer + 6° C. [42°·8 F.], barometer 753·5 mm. [29·67 ins.] (deducting the altitude of the place). We noted also that the electrical discharges on our anchor only ceased a very short time before we came out of the clouds. A heavy fall of snow lasted 30 to 35 minutes after our landing.

Might we therefore suppose that during the vertical ascent from 600 m. to 1900 m. [6230 ft.] without throwing out any ballast, without sunshine, and in the full force of the hail, the balloon was charged with electricity, and that a tremendous expansion of gas took place?"

Climatic Change in Egypt.

The climate of Egypt, though perhaps it could not be described as interesting in the sense that the climate of England, characterised by almost every conceivable variety and rapid change of weather, is interesting, should perhaps, in virtue of the simpler and more constant state of the weather and seasons, afford more certain or more easily ascertained indications of the existence of any definite climatic change operating through a long series of years. The

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subject has been dealt with by Mr. B. F. E. Keeling in the *Cairo Scientific Journal* for January 1909. There is a wide-spread belief that, through increased irrigation, Egypt is becoming colder and damper, and Mr. Keeling has endeavoured to show that meteorological records do not support the popular contention. The temperature records of the Abbassia Observatory, where observations have been made since 1869, show no certain indication of any decrease of mean annual temperature, which ranges about 21° C. (69°·8 F.). The relative humidity values likewise indicate no decided change of climate during the last forty years. The driest year was 1892, with 7 mm. of rain (0·3 in.), and the wettest 1904, with 73 mm. (2·9 ins.). At Cairo the mean annual rainfall is 30 mm. (1·2 in.), which falls for the most part in occasional showers and drizzles. Heavy rain-storms sometimes occur in Cairo, but in Upper Egypt rain is very rare. Egypt does not appear to be quite out of the region of frost and snow, but these winter phenomena are rare. Thus at Abbassia since 1880 there have been only three frosts, the severest being − 2° C. (28°·4 F.) in 1880, and − 4° C. (24°·8 F.) in 1905. Historical records show that frost was not more frequent in the past, and was always sufficiently rare to be worthy of remark. During the winters of 829 and 1010 A.D. ice was reported on the Nile. There appears, however, in spite of the absence of evidence of any progressive change of climate, to be a well-marked periodicity of mean annual temperature, shown by the Abbassia records, coinciding with the eleven-year sunspot period—excess of temperature occurring with excess of sunspots. In the hot, dry Egyptian climate sunspot influence would probably be less easily masked by other more powerful atmospheric influence than in cold, cloudy northern countries. The climate of Egypt is, in fact, more favourable to the study of astronomy than of meteorology.—*Geographical Journal*, August 1909.

Ball Lightning.

Mr. ALFRED HANDS, in a letter to the *English Mechanic*, August 13, in reply to some correspondence on "Fireballs," said:—It is an undoubted fact that effects have been observed during thunderstorms giving the idea of luminous spheres of various sizes; but in the reports of most of these there has been nothing to lead one to suppose them other than the glow of brushing effects, generally called St. Elmo's Fire, that would naturally appear on pointed objects or sharp edges. These are generally stationary, but may move along a sharp edge, such as a metal ridge, or even a stretched wire. They indicate that a very severe electrical stress is in progress—that, in fact, a lightning-flash is on the verge of occurring to that spot. As the cloud moves overhead the stress may be shifted so that the brush appears successively on a number of pointed objects, such as a row of trees, and then the "ball" is supposed to have travelled through the air from one to the other, or, if the stress increases sufficiently, the flash may occur, and then the observer, who has been watching the "ball," and not the air space above it, presumes it has burst.

The evidence in favour of there being a distinct type of lightning that may be called "globular" or "ball," because it takes the form of a luminous sphere travelling more or less slowly through the air, is, in my opinion, very slender. Such phenomena would not only be inconceivable from the point of view of modern knowledge, but even, I think, in opposition thereto. The difference between brushing effects and what could rightly be called "ball lightning" lies entirely in the matter of the "ball" travelling through the air, quite apart from any connection with terrestrial objects, and it is just on this point that I have found observers to fail when closely questioned. Out of many cases I have investigated I select the following:—

1. *Bradford.*—On a squally and thundery day, but not during a thunder-

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storm, a ball of fire, said to be two or three feet in diameter, was reported to have travelled across a golf-course and through a cemetery.

2. *Rugby.*—A gentleman, while going up the stairs in his house, saw, through a window he was passing, a ball of fire on the top of a tree in his garden. He hurried upstairs to another window to get a better view, and said that, while still on the stairs, and before he reached the window, he saw it pass through the air to another tree, and just as he got to the window it burst, wrecking the tree.

3. *Haslemere.*—A church was struck by a ball of fire that was seen, by people seated at tea in a room, to be travelling through the air.

4. *Hampstead.*—A house was struck by lightning, and I was told by the owner that at the same moment his two daughters, who were looking out of different windows at the back of the house, saw a ball of fire fall on the lawn, some distance from the chimney that was struck.

5. *Leamington.*—A house was struck, and a passing cyclist saw a ball of fire in the road in front of the house.

The results of my investigations were as follows:—

1. When questioned, witnesses said the "ball" looked white or silvery; one described it as a tapering pillar, not unlike frothy water. Inspection of the cemetery showed that, along the track it had followed, glass covers and earthenware jars on the graves had been thrown over, and splashes of earth had been washed up on to the headstones. The course was a rather tortuous one, and railings and other metal objects had in some cases been passed over, and in others avoided. I came to the conclusion that this was somewhat of the nature of a small waterspout.

2. On going up the staircase with the owner I found that, on reaching the top stair, I had to walk some distance along a passage to the window before either of the trees were visible. He could not, therefore, have seen the "ball" pass through the air while he was on the stairs, and probably, having seen it on one tree from the first window, and then on another one from the second, he presumed it must have travelled across. The upper part of the tree was shattered, and down the trunk a groove had been cut in the bark in precisely the way that elm-trees are often damaged when struck by lightning.

3. The course said to have been followed by the "ball" coincided with the tops of a row of fir-trees, and I think the appearance of the brush successively on different trees conveyed the impression of its travelling. The damage to the church differed in no respect from ordinary lightning effects.

4. I pointed out three metal gullies in the path at the edge of the lawn where glow effects would be liable to occur. The owner questioned his daughters again, and one indicated the spot as being on the lawn, close to the first gully, and the other a similar spot near the third one. Each lady could see one gully only, the second being invisible to both, and neither saw the "ball" fall through the air.

5. The position where the "ball" was seen was over a metal gully at the side of the road, and it was stationary and momentary.

Flammarion, in his *Thunder and Lightning*, records some remarkable cases of so-called globular lightning, and other writers have given inexplicable examples; but I think all these, if intelligently investigated on the spot, would have proved to be as simple as the few I have quoted.

On an old gilded picture-frame I can easily produce what appear to be very small balls of light rolling about, but I think these are due to minute sparks occurring successively across cracks in the gilding, and that the spherical forms and rolling effects are optical illusions.

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Distribution of Precipitation in the Western Sudan.

An article by M. Lucien Marc in the *Annales de Geographie* (97) deals with this question, and brings out some interesting points. The area dealt with is that included between the coast of Guinea and the loop of the Niger. In this area meteorological figures are unfortunately available only for a limited period, so that the conclusions drawn are necessarily somewhat provisional in character. The paper gives maps and diagrams showing the distribution of rain during the different months, but the following are the chief points of general interest. In the first place, it is to be noted that in Africa, as contrasted with the other continents, the distribution of rainfall throughout the year is determined solely by the (apparent) movements of the sun. The influence of the monsoons extends to some extent inwards, it is true, from the eastern seaboard, but in all the western and central region it would seem to be only the periodical displacement of the zone of tropical calms which influences precipitation. In Africa this zone extends over some 12 to 16 degrees of latitude. In the centre of the zone is a region of virtually daily rainfall; in passing from this centre the precipitation diminishes in amount, until outside the limits of the zone there is total drought. The displacement in latitude of the zone of calms varies in different regions, but in general terms it may be said that the oscillations reach their minimum in Central Africa, and their maximum in Western Africa. It is apparently to the north of Timbuktu that is found the most elevated latitude in which tropical rains occur.

As a result of the movements of the zone it is found that in all the region under discussion there is a dry season from November to January, a small amount of rain occurring in February in the southern part of the region. From February onwards the rains progressively increase. As regards the maximum two conditions occur. About Gambaga (lat. approx. 10° N.) there is a maximum about the end of May or beginning of June, a minimum in July, and a new maximum towards the end of August. At Wagadugu (lat. about 12° N.) there is one maximum in August. The limit between the two regions occurs in about 11° N. These facts have considerable economic importance. In the region where two rainy seasons occur the natives reap two harvests from the same field each year. At the end of March a millet of rapid growth is sown, which is reaped at the beginning of July. As soon as the harvest is reaped sorghum is sown, which is reaped at the beginning of November. Where there is only one rainy season two crops cannot be obtained.

The rainfall of course diminishes towards the north, but the limit to which tropical rains extend is not easy to fix. It is certainly north of Timbuktu, and perhaps reaches the tropic. The Niger territories receive proportionately much more rain than the Nile valley. Thus Timbuktu, in 16° 43′ N. lat., receives more than twice as much rain as Khartum, in 15° 36′ (236 mm. or 9·3 ins. against 107 mm. or 4·2 ins.).—*Scottish Geographical Magazine*, August 1909.

The Climate of the Orinoco and Rio Negro.

In a paper on the region of the Orinoco and Rio Negro, printed in the *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, 1909, No. 2, Herr A. Jahn gives, *inter alia*, the results of observations carried out by himself as regards the climatology of the region. The mean temperature for the year 1887 at Ciudad Bolivar, on the Orinoco River in the lower part of its course, was 83°·1 F. There is a decided decrease of temperature towards the Atabapo and Rio Negro Rivers on the borders of Venezuela and Brazil, partly referable to abundance of wood and moisture and excessive cloudiness. The humidity of the air is especially great in the neighbourhood of the Yavita water-parting between the Atabapo and Rio Negro Rivers, where at Pimichin the sky is nearly always clouded, and where it rains even during the Venezuelan "verano," *i.e.* during

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the dry season between January and April. Here it rains almost the whole year round (December and January excepted), and even in the dry season one seldom sees blue sky for more than two or three days in succession. Over the upper Rio Negro, above Marabitanos, the regular tropical dry season disappears, and there is a perpetual alternation of sunshine and shower even during the height of the Amazon summer, from June to September. Over the Orinoco the case is different. The course of this river runs through a steppe region with wooded margins, a character which sufficiently explains the smaller precipitation and lower humidity as indicated by psychrometer observations made in 1887. The lower course of the river belongs, from a general as well as from a geological point of view, to the Llanos region, and in common with it has its rainy season extending from May to December. During March and April, when the dry season of the Llanos has reached its height, the greatest precipitation occurs over the lower Amazon south of the equator. Then the Llanos exert an aspirating effect, drawing the saturated and cooler air of the Amazon towards the north, whereby the moisture is precipitated on the elevated watershed which forms the boundary between Venezuela and Brazil.—*Geographical Journal*, August 1909.

RECENT PUBLICATIONS

British Rainfall, 1908. *On the Distribution of Rain in Space and Time over the British Isles during the year* 1908, *as recorded by more than* 4500 *Observers in Great Britain and Ireland, and discussed with Articles upon various branches of Rainfall Work.* By HUGH ROBERT MILL. London, 1909. 8vo. 100 + 304 pp.

THIS is the forty-eighth annual volume, and is larger by 24 pages than any previous issue of *British Rainfall*. We fully endorse Dr. Mill's statement "that no part of this volume is a repetition of last year's or any other year's issue. Every page is written for this issue alone, and every illustration specially prepared for it." The illustrations are not only numerous, but they are very clearly prepared and printed, and add greatly to the attractiveness of the book.

There are four special articles, viz. :—(1) "New Recording Rain Gauges," by Dr. H. R. Mill, in which are described the Halliwell patent Recording Rain Gauge, and Messrs. Negretti and Zambra's latest new instrument "The Hyetograph." (2) "Ratio of Monthly Rainfall between Denton House, Brampton, and Seathwaite," by T. G. Charlton. (3) "Rainfall Observations in Snowdonia," by A. Lockwood. Thirteen rain gauges have been fixed in what is naturally the wettest portion of Snowdonia. One of these gauges during 1908 collected as much as 237·32 ins. of rainfall. It is probable that this will now have to be considered as "the wettest spot" in the British Isles. (4) "Twenty years' Rainfall at Carrablagh, Co. Donegal."

Meteorological Office. The Observer's Handbook. Approved for the use of Meteorological Observers by the Meteorological Office, the Royal Meteorological Society, the Scottish Meteorological Society, the British Rainfall Organization. Annual Edition, 1909. Published by the Authority of the Meteorological Committee. M.O. 191. London, 1909. 8vo. 154 pp. Price 3s.

This Handbook, which is in continuation of Dr. Scott's *Instructions in the Use of Meteorological Instruments* (published in 1877), has been prepared by Mr.

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R. G. K. Lempfert, the Superintendent of the Statistical Branch of the Meteorological Office. It has been written primarily for the use of the observers of the Meteorological Office, and follows the decisions of the International Conferences, wherever they bear upon the meteorological practice in this country. Arrangements have been made for the issue each year of a small edition to be printed from standing type, with such alterations as are found necessary to keep pace with the advancement of the science.

In revising the edition for 1909, the Director of the Meteorological Office has taken the opportunity to obtain the approval of the volume by the Royal Meteorological Society, the Scottish Meteorological Society, and the British Rainfall Organization, for the use of observers connected with those institutions. He says that "since Meteorological Science is entirely of a co-operative character, and observations are only useful in so far as they are comparable with those made in other places or at other times, it is clear that instructions in the use of instruments are only satisfactory in so far as they represent the general consensus of opinion as distinguished from the opinion of a single institution or individual. It is therefore an essential condition of progress that the arrangements for making and recording observations should be the subject of common agreement between the institutions responsible for the control of the various parts of the network of stations in this country."

The Handbook is divided into three sections. Part I. deals with the instruments and observations at ordinary meteorological stations; and Part II. with self-recording instruments; while Part III. is devoted to additional instruments and observations.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of more general interest.

[Abbe, C.]—A Chronological Outline of the History of Meteorology in the United States of North America. *Monthly Weather Rev., Washington*, **37**, 1909 (87-89).

Alessandri, C., e Eredia, F.—Andamento diurno della pressione barometrica dell' umidità relativa e della tensione del vapore alla Capanna Margherita e ad Alagna. *R. Accad. d. Lincei, Rome, Cl. sci. fis. math. e nat.*, ser., 5, **18**, Rome, 1909 (47-52).

Alippi, T.—La previsione del tempo. *Rivista Meteorico-Agraria, Rome*, **30**, 1909 (390-394).

Arctowski, H.—The Climate of the Glacial Epoch. *Monthly Weather Rev., Washington*, **37**, 1909 (26-27).

Assmann, R.—Zwei Blitzschläge in Drachen am Kgl. Aeronautischen Observatorium Lindenberg. *Wetter, Berlin*, **26**, 1909 (111-116).

Barbe, G.—Sur les périodes très pluvieuses dans quelques stations françaises. *Ann. Soc. Mét. France, Paris*, **57**, 1909 (89-92).

Bauer, L. A.—A Plea for Terrestrial and Cosmical Physics. *Monthly Weather Rev., Washington*, **37**, 1909 (27-29).

Besson, L.—Sur l'arc circumzénithal. *Ann. Soc. Mét. France, Paris*, **57**, 1909 (65-72).

Besson, L.—Sur les alignements dans les nuages. *Ann. Soc. Mét. France, Paris*, **57**, 1909 (85-88).

Bigelow, F. H.—Studies on the Phenomena of the Evaporation of Water over Lakes. *Monthly Weather Rev., Washington*, **36**, 1908 (437-445).

Bigelow, F. H.—Studies on the Vortices in the Atmosphere of the Earth. *Monthly Weather Rev., Washington*, **37**, 1909 (48-53).

Digitized by Google

Blair, W. R.—Storm Depth, Rate of Movement, and Intensity. *Bull. Mount Weather Obs., Washington*, **2**, 1909 (72-74).

Blair, W. R.—The Exploration of the Upper Air by means of Kites and Balloons. *Proc. Amer. Phil. Soc., Philadelphia*, **48** (8-33 and pl.).

Blair, W. R. and Ross, L. C.—Stationary Clouds to the Leeward of Hill and Mountain Ranges. *Bull. Mount Weather Obs., Washington*, **2**, 1909 (75-77).

Bonacina, L. C. W.—On M. Angot's Studies on the Temperature of France. *Symons's Met. Mag., London*, **44**, 1909 (94-97).

Bonacini, C., e Nicolis, U.—Misure di conducibilità elettrica dell' aria eseguite sul Monte Cimone nell' estate del 1908. *Pubblicazioni del R. Oss. Geofisico di Modena No. 24, Modena*, 1909.

Börnstein, R.—Der norddeutsche Prophetentag vom 1 März d. J. *Wetter, Berlin*, **26**, 1909 (91-96).

Boutquin, A.—L'Asie Centrale. *Ciel et Terre, Brussels*, **30**, 1909 (155-166, 227-237).

Brabant, W. v.—Quelques mots sur le climat de la Bolivie. *Ciel et Terre, Brussels*, **30**, 1909 (261-265).

Brazier, C. E.—Étude d'un barographe métallique à poids tenseur construit par la Maison Richard. *Ann. Soc. Mét. France, Paris*, **57**, 1909 (109-113).

Clayton, H. H.—The Meteorology of Total Solar Eclipses including the Eclipse of 1905. *Ann. Astronomical Obs., Harvard College, Cambridge*, **58**, 1908 (192-216).

Clayton, H. H.—Adopt the Kelvin Thermometer Scale and the Metric System. *Monthly Weather Rev., Washington*, **37**, 1909 (92).

Clayton, H. H. and Fergusson, S. P.—Exploration of the Air with Ballons-sondes, at St. Louis, and with Kites at Blue Hill. *Ann. Astronomical Obs., Harvard College*, **68**, Part I., *Cambridge*, 1909 (1-92 and 11 pl.).

Coronas, Rev. J.—The "Tarlac" Typhoon, September 18-27, 1908. *Bull. Weather Bureau, Manila*, 1908, Manila, 1909.

Czermak, P.—Zur Wolkenform des aufsteigenden Luftstromes. *Meteor. Zeits., Brunswick*, **26**, 1909 (210-212 and pl.).

Daunderer, A.—Über die in den unteren Schichten der Atmosphäre vorhandene freie elektrische Raumladung. *Meteor. Zeits., Brunswick*, **26**, 1909 (301-311).

Ellemann, F.—Ueber die meteorologische und kulturhistorische Bedeutung der Wetter- und Bauernregeln. *Wetter, Berlin*, **26**, 1909 (145-157).

Eredia, F.—L'alluvione nei versante orientale della Sicilia del Novembre 1908. *Riv. Met. Agraria, Rome*, **30**, 1909 (289-306).

Ficker, H. von.—Der Einfluss orographischer Verhältnisse auf die Niederschläge in Tirol und Vorarlberg. *Meteor. Zeits., Brunswick*, **26**, 1909 (311-315).

Fripp, C. E., and Fripp, F. E. B.—Rainfall of Southern Rhodesia. *Geog. Teacher, London*, **5**, 1909 (77-81).

Gheury, M. E. J.—Suggested Reforms in Meteorological Methods. *Monthly Weather Rev., Washington*, **37**, 1909 (91-92).

Gheury, M. E. J.—The Specific Gravity of Snow. *Monthly Weather Rev., Washington*, **37**, 1909 (98-100).

Hall, A. D.—How Climate and Soil Influence Farm Crops. *J. Farmer's Club, London*, **1909** (839-846).

Hamburg, Deutsche Seewarte.—Die Eisverhältnisse an den deutschen Küsten im Winter 1908-9. *Ann. d. Hydrog. Marit. Met., Berlin*, **37**, 1909 (287-296).

Hann, J.—Klima am unteren Zambesi. *Meteor. Zeits., Brunswick*, **26**, 1909 (277-280).

Hann, J.—Die meteorologischen Ergebnisse der englischen antarktischen Expedition 1901 bis 1904. *Meteor. Zeits., Brunswick*, **26**, 1909 (289-301).

Harries, H.—A Visit to Dr. von Neumayer. *Symons's Met. Mag., London*, **44**, 1909 (84-86).

Harries, H.—(Obituary notice of) Dr. von Neumayer, For. Mem. R.S. *Nature, London*, **80**, 1909 (402-403).

Hellmann, G.—L'aurore de la Météorologie. *Ciel et Terre, Brussels*, **30**, 1909 (179-187 203-209).

Digitized by Google

Henry, A. J.—Great Inversions of Temperature. *Monthly Weather Rev., Washington*, 37, 1909 (22).

Humphreys, W. J.—Summer and Winter Vertical Temperature Gradients. *Monthly Weather Rev., Washington*, 37, 1909 (10-11).

Huntington, E.—The Climate of Ancient Palestine. *Bull. Amer. Geog. Soc., New York*, 40, 1908 (513-522, 577-586, 641-652).

Huntington, H.—The Climate of the Historic Past. *Monthly Weather Rev., Washington*, 36, 1908 (446-450).

Jochimsen.—Der Winter in Schleswig-Holstein. *Wetter, Berlin*, 26, 1909 (97-104).

Joester, K.—Die Föhnerscheinungen im Riesengebirge. *Wetter, Berlin*, 26, 1909 (79-84).

Kähler, K.—Registrierungen des luftelektrischen Potentialgefälles an nahe benachbarten Stationen. *Meteor. Zeits., Brunswick*, 26, 1909 (347-355).

Kimball, H. H.—Pyrheliometer and Polarimeter Observations. *Bull. Mount Weather Obs., Washington*, 2, 1909 (55-65).

Knoche, W.—Über elektrische Entladungen in der Kordillere. *Meteor. Zeits., Brunswick*, 26, 1909 (355-360).

Knox, A.—The Isohyets 'twixt Sahara and Western Sudan. *Geog. J., London*, 33, 1909 (697-702).

Köppen, W.—Vorschlag, alle Luftdruck messungen in allgemeinem Kraftmass anzugeben. *Meteor. Zeits., Brunswick*, 26, 1909 (198-201).

Köppen, W.—Express all Barometric Measurements by Ordinary General Units of Force. *Monthly Weather Rev., Washington*, 37, 1909 (92-93).

Kremser, V.—Ergebnisse vieljähriger Windregistrierungen in Berlin. *Meteor. Zeits., Brunswick*, 26, 1909 (259-265).

Lempfert, R. G. K.—International Meteorological Meeting in London. *Symons's Met. Mag., London*, 44, 1909 (103-105).

Livingston, Mrs. G.—An Annotated Bibliography of Evaporation. *Monthly Weather Rev., Washington*, 37, 1909 (68-72, 103-109).

Maillet, E.—Les crues en 1907 dans divers bassins fluviaux. *Ann. Soc. Mét. France, Paris*, 57, 1909 (133-136).

Maring, D. T.—Weather Bureau Kiosks. *Monthly Weather Rev., Washington*, 37, 1909 (89-91).

Martin, E. A.—Some Observations on Dew-ponds. *Geog. J., London*, 34, 1909 (174-191).

Marvin, C. F.—The Pressure of Saturated Vapour from Water and Ice as measured by Different Authorities. *Monthly Weather Rev., Washington*, 37, 1909 (3-9).

Marvin, C. F.—A Proposed New Formula for Evaporation. *Monthly Weather Rev., Washington*, 37, 1909 (57-61).

Maurer, J.—Über die Veränderlichkeit der Lufttemperatur für das Schweizergebiet. *Meteor. Zeits., Brunswick*, 26, 1909 (315-318).

Meissner, O.—Einige Bemerkungen zur atmosphärischen Optik. *Wetter, Berlin*, 26, 1909 (157-159).

Mill, H. R.—The Rainfall of the British Isles. *Geog. Teacher, London*, 5, 1909 (66-77).

[Mill, H. R.]—(Obituary Notice of) George von Neumayer, 1826-1909. *Symons's Met. Mag., London*, 44, 1909 (83-84 2nd pl.).

Moore, W. L.—Annual Report of the Chief of the Weather Bureau, for the Fiscal Year ending June 30, 1908. *Monthly Weather Rev., Washington*, 36, 1908 (454-465).

Mossman, R. C.—The Meteorology of the Weddell Quadrant and Adjacent Areas. *Trans. Roy. Soc., Edinburgh*, 47, 1909 (103-136 and 5 pl.).

Mossman, R. C.—The Greenland Sea: Its Summer Climate and Ice Distribution. *Scot. Geog. Mag., Edinburgh*, 25, 1909 (281-310 and map).

Mossman, R. C.—Meteorology at the South Orkneys and South Georgia in 1908. *Scot. Geog. Mag., Edinburgh*, 25, 1909 (408-413).

Nichols, E. L.—A Study of Overcast Skies. *Monthly Weather Rev., Washington*, 37, 1909 (18-21). Reprinted from *Physical Rev., Lancaster*, 28, 1908 (122-131).

Digitized by Google

Nichols, E. L.—Theories of the Color of the Sky. *Monthly Weather Rev., Washington*, **37**, 1909 (15-16).

Observations météorologiques faites à Ayata et à Sidi-Yahia (Algérie). *Ann. Soc. Mét. France, Paris*, **57**, 1909 (137-139).

O'Connell, Col. M. D.—Climate (Meteorological Environment) as a Possible Cause of Pyrexia. *Journal of Tropical Medicine and Hygiene, London*, March 15, 1909.

O'Gara, P. J.—A Portable Rotation Psychrometer. *Monthly Weather Rev., Washington*, **37**, 1909 (22-23).

Palmer, W. S.—Some Climatic Features of Wyoming and their Relation to Dry Farming. *Monthly Weather Rev., Washington*, **37**, 1909 (54-56).

Patterson, J.—The Simla Seismograms obtained between June 1905 and November 1908. *Indian Met. Memoirs, Simla*, **20**, 1909 (33-52. Appendix i.-xi. and 12 pl.).

Petermann, E.—Frühling in Wien, Berlin, Petersburg. *Wetter, Berlin*, **26**. 1909 (138-141).

Rotch, A. L.—The Eclipse Shadow-Band. *Ann. Astronomical Obs., Harvard College, Cambridge*, **58**, 1908 (217-222).

Rudel, Prof.—Gewitterhäufigkeit zu Nürnberg 1879 bis 1908. *Wetter, Berlin*, **26**, 1909 (104-107).

S., G. F. H.—Frost and Ice Crystals. *Nature, London*, **80**, 1909 (492-494).

Schiötz, O. E.—Zur Frage der durch den Wind erzeugten Meeresströmungen. *Ann. d. Hydrog. Marit. Met., Berlin*, **37**, 1909 (254-261).

Schmauss, A.—Die obere Inversion. *Meteor. Zeits., Brunswick*, **26**, 1909 (241-258).

Schubert, J.—Die Witterung in Eberswalde im Jahre 1907. *Wetter, Berlin*, **26**, 1909 (73-79).

Schwalbe, G.—Die Gesetze der allgemeiner Temperaturverteilung auf der Erdoberfläche. *Wetter, Berlin*, **26**, 1909 (121-126).

Schwendig, E.—Beobachtungen der Temperatur und des Salzgehalts der Meeresoberfläche zwischen Suez und Sydney. *Ann. d. Hydrog. Marit. Met., Berlin*, **37**, 1909 (351-556).

Simonsen, A.—Dampferreisen von Portland (Oregon) und Seattle nach Yokohama oder Wladiwostok auf dem Wege nördlich von den Aleuten. *Ann. d. Hydrog. u. Marit. Met., Berlin*, **37**, 1909 (357-363).

Solyom, H. L.—Argentine Weather. *Monthly Weather Rev., Washington*, **37**, 1909 (96-98).

Steen, A. S.—Einige Studien über die Bewolkung. *Meteor. Zeits., Brunswick*, **26**, 1909 (201-209).

Sutton, J. R.—Earth Temperatures at Kimberley. *Trans. S. African Phil. Soc.*, **18**, 1909 (421-435).

Tetens, O.—Meteorological Registrations in Samoa 1902-1906. I. Winds. *Monthly Weather Rev., Washington*, **37**, 1909 (93-95).

The Aurora Polaris. *Monthly Weather Rev., Washington*, **37**, 1909 (16-18).

Trabert, W.—Dr. Joseph Maria Pernter. *Meteor. Zeits., Brunswick*, **26**, 1909 (193-198 and pl.).

Ulrich, Capt. H.—Orkan bei den Comoren am 14 und 15 April 1908. *Ann. d. Hydrog. Marit. Met., Berlin*, **37**, 1909 (261-264).

Vanderlinden, E.—La foudre et les arbres. Étude sur les foudroiements d'arbres constatés en Belgique pendant les années 1884-1906. *Ann. Obs. Roy. Belg., Brussels*, **20**, 1909, part 3.

Wahlburg, E. S. E. von.—Ueber Wintergewitter. *Wetter, Berlin*, **26**, 1909 (127-132).

Weidenhagen, R.—Die Vortragstätigkeit des Wetterdienstleiters. *Wetter, Berlin*, **26**, 1909 (142-144).

Weinberg, B.—The Crystallization of Undercooled Water. *Monthly Weather Rev., Washington*, **37**, 1909 (14-15).

Woeikof, A.—Klima von Snow-Hill, Grahamland, nach den Beobachtungen der schwedischen Südpolarexpedition. *Meteor. Zeits., Brunswick*, **26**, 1909 (337-347).

Worth, R. H.—Twenty-sixth Report (Third Series) of the Committee on the Climate of Devon. *Trans. Devon Assoc., Plymouth*, **40**, 1908 (86-101).

Yapp, R. H.—On the Stratification in the Vegetation of a Marsh, and its Relations to Evaporation and Temperature. *Annals of Botany*, **23**, 1909 (275-319 and pl.).

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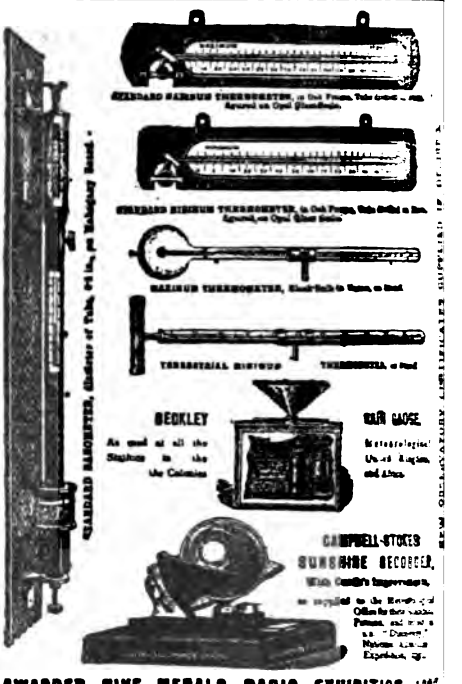
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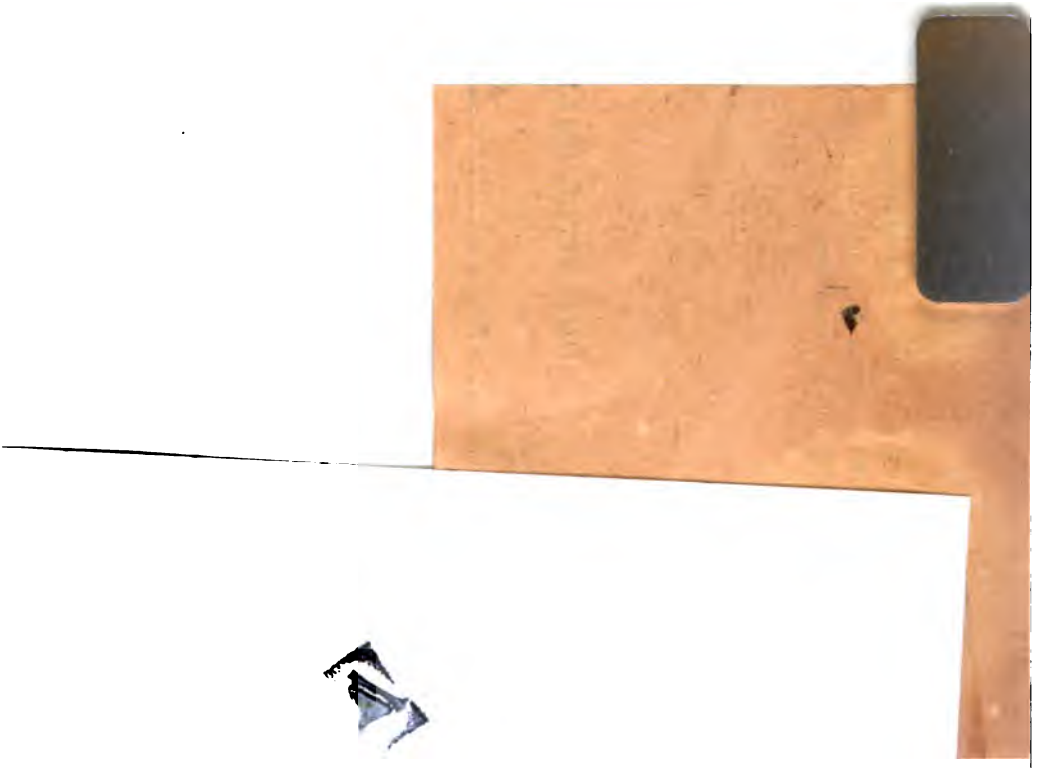
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